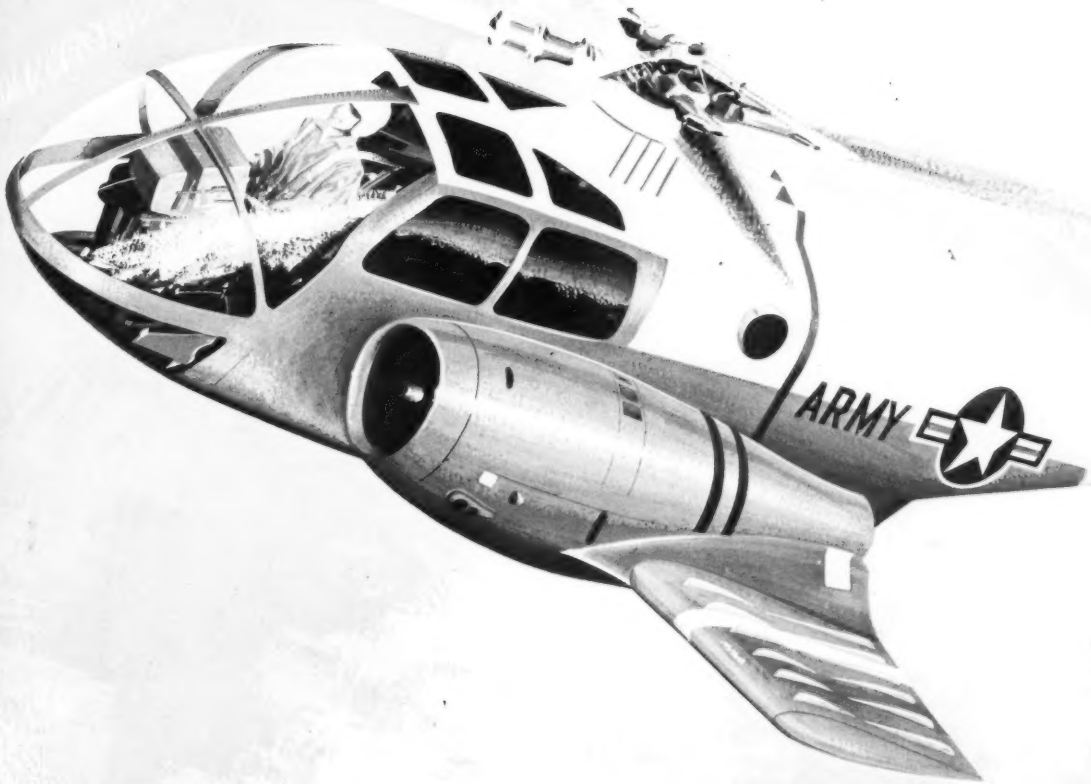
PROPERTY OF
THE LIBRARY

11 JUN 1965

USAF ACADEMY



CARTER

UNITED STATES ARMY AVIATION DIGEST

DIRECTOR OF ARMY AVIATION, ACSFOR
DEPARTMENT OF THE ARMY
Col George P. Seneff, Jr.

COMMANDANT, U. S. ARMY AVIATION SCHOOL
Brig Gen John J. Tolson, III

ASST COMDT, U. S. ARMY AVIATION SCHOOL
Col George W. Putnam, Jr.

EDITORIAL STAFF

Capt Richard C. Anglin
Fred M. Montgomery
Richard K. Tierney
William H. Smith
Diana G. Williams

GRAPHIC ART SUPPORT

H. G. Linn
H. A. Pickel
D. L. Crowley
A. Lofe

USABAAR EDUCATION AND LITERATURE DIV

Pierce L. Wiggin
William E. Carter
Ted Kontos
Charles Mabius

MAY 1965 VOLUME II NUMBER 5

Escort of Airmobile Formations, Maj John R. Baird and Maj George E. Burnison 1
LORAN-D 5
Try FM Homing, Capt Robert H. Stepp 6
Evolution, John B. Galipault 8
Density Altimeter, Capt John A. G. Klose 10
Protective Headgear, Maj George W. Aldridge, Jr. 12
UH-1 Collective Bounce, Capt Edgar A. Westlake 16
Bottle to Throttle, Capt George W. Ingraham 19
Flight Following System 22
A Helping Hand, William H. Smith 23
Low Level Location of an LZ, Capt Thomas K. Phifer 26
All Work and No Play 29
Low Power Turbine Operation, Sam Baker 33
What is Compressor Stall? Sam Baker 34
Unhappy Turn, LCdr J. T. Gilstrap 38
Crash Sense 41
Usual Duty in an Unfamiliar Country Inside Back Cover
World's Fastest Rotorcraft Back Cover

The mission of the U. S. ARMY AVIATION DIGEST is to provide information of an operational or functional nature concerning safety and aircraft accident prevention, training, maintenance, operations, research and development, aviation medicine, and other related data.

The DIGEST is an official Department of the Army periodical published monthly under the supervision of the Commandant, U. S. Army Aviation School. Views expressed herein are not necessarily those of Department of the Army or the U. S. Army Aviation School. Photos are U. S. Army unless otherwise specified. Material may be reprinted provided credit is given to the DIGEST and to the author, unless otherwise indicated.

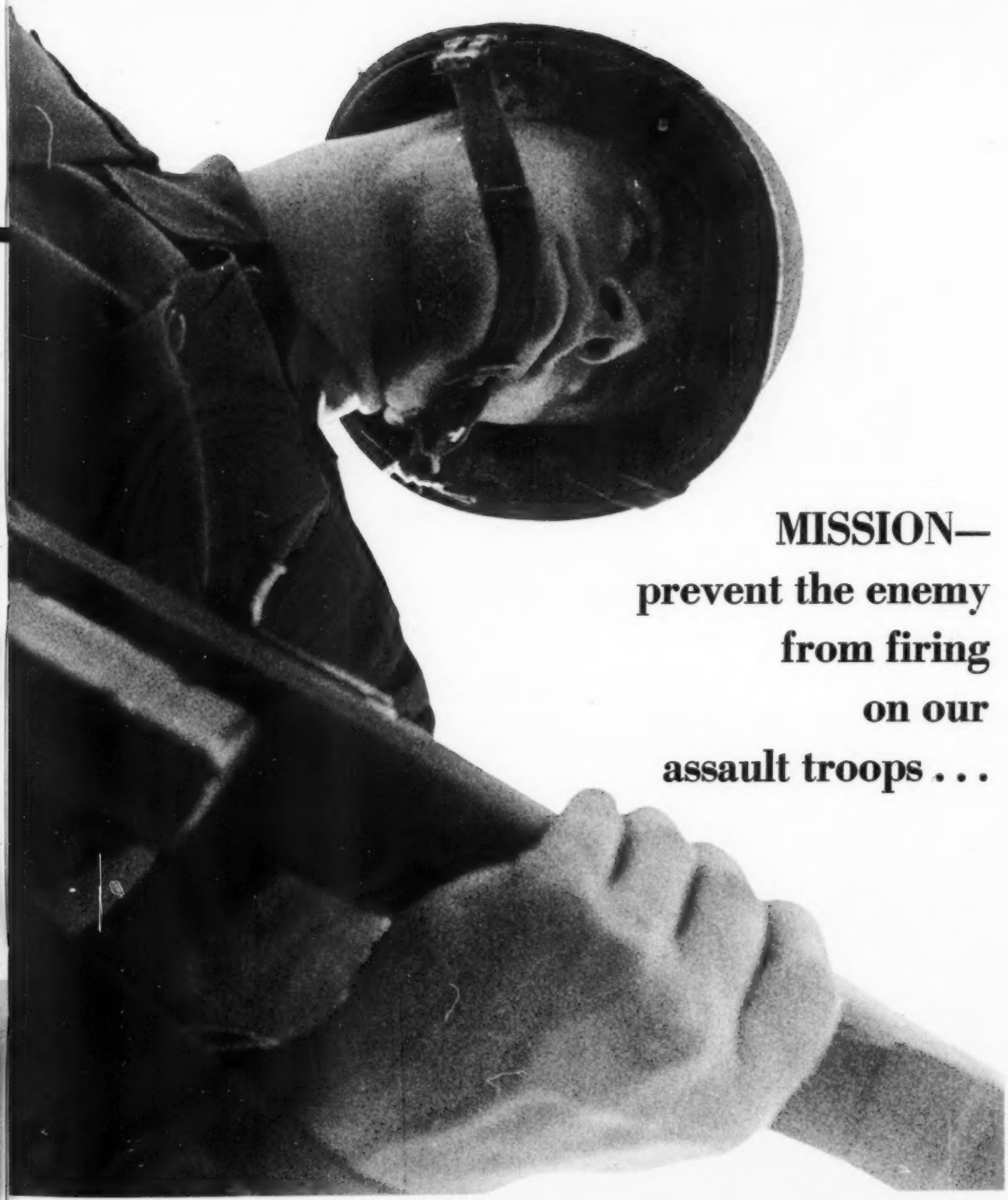
Articles, photos, and items of interest on Army Aviation are invited. *Direct communication is authorized to: Editor-in-Chief, U.S. Army Aviation Digest, Fort Rucker, Alabama.*

Use of funds for printing this publication has been approved by Headquarters, Department of the Army, 29 December 1964.

Active Army units receive distribution under the pinpoint distribution system as outlined in AR 310-1, 20 March 62, and DA Circular 310-57, 14 March 63. Complete DA Form 12-4 and send directly to CO, AG Publications Center, 2800 Eastern Boulevard, Baltimore, Md. For any change in distribution requirements, merely initiate a revised DA Form 12-4.

National Guard and Army Reserve units submit requirements through their state adjutants general and U. S. Army Corps commanders respectively.

For those not eligible for official distribution or who desire personal copies of the DIGEST, paid subscriptions, $4.50 domestic and $5.50 overseas, are available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.



MISSION—
prevent the enemy
from firing
on our
assault troops . . .

needed: effective suppressive fire

Escort Of Airmobile Formations

Major John R. Baird and Major George E. Burnison

Fixed wing escorts should be free to suppress enemy targets outside the immediate landing area during troop debarkation

LET US APPLY two facets of any engagement, firepower and maneuver, to an airmobile operation. Three assumptions are made: that troop carrier formations require protection against enemy air and ground forces; that the control of the skies is the mission of Tactical Air and will remain the responsibility of the Air Force; and that the suppressive fires required against enemy ground elements require both fixed and rotary wing armed aircraft, or aircraft having the flight characteristics of these types.

What are the requirements for suppressive fire against enemy ground forces? Basically, there are three. They remain constant in both conventional warfare and in counterinsurgency, and can be identified as follows:

• In the loading zone an observation and limited suppressive fire capability is required. This is to counter the potential threat from guerillas in an insurgency situation. It is also required to counter the guerillas and for enemy forces operating in our rear areas in a "conventional" war under the dispersion conditions demanded on a nuclear battlefield.

• A suppressive fire capability must be immediately available to counter enemy forces en route, both to and from the assault landing area.

• A suppressive fire capability must be in the assault landing

The views and opinions expressed herein are the writers' and are not to be considered as an official expression of the Department of Defense.

Control of the skies is a tactical Air Force responsibility

zone to deliver preparatory fires, suppressive fires during the actual assault landing, and suppressive fires on weapons and enemy personnel immediately outside the assault landing zone which pose a threat to the operation.

What type aircraft can most effectively satisfy these three requirements? In discussing aircraft, the terms fixed wing aircraft and rotary wing aircraft indicate flight characteristics common to these types. Aircraft having like characteristics and capabilities can be substituted when available.

Armed fixed wing aircraft provide the most effective cover and suppressive fire capability in the loading zone for two reasons: First, they currently enjoy a considerable endurance advantage over rotary wing and so can perform this function and still assume further missions generated by the airmobile operation without refueling. Second, they can carry considerably more ordnance than the helicopter, precluding reloading requirements.

Fixed wing aircraft envisioned are of the AD-6 type, aircraft possessing endurance of 4 to 6 hours and the capability of carrying several tons of ordnance. The source of these aircraft is incidental to the job to be accomplished. It makes no difference, sister service or allied nation, the primary concern is availability and responsiveness of proper types.

Fixed wing aircraft will provide the optimum escort en route to and from the assault landing zone. Again, they have the endurance and ordnance. In addition, they have a sufficient speed differential to allow suppressing enemy positions en route, remaining on target until the troop carriers pass, and rejoining the troop carriers for further requirements.

It must be noted that current and proposed helicopters do not have the speed to suppress an enemy position en route and then rejoin the formation to resume their escort mission. Once committed en route, the helicopter must be considered lost to the remainder of the operation. Should they be able to rejoin the formation, this must be considered a bonus effect.

In the assault landing zone, the fixed wing aircraft can deliver preparatory fire, then shift to known or suspected target areas immediately outside the actual landing zone. This must be done on plan and the fire shifted only when escort helicopters actually begin delivering suppressive fire against the assault landing zone. The fixed wing aircraft will be free to suppress enemy targets outside the immediate landing area during the conduct of the landing.

The helicopter escort will deliver the final suppressive fire im-

---

Maj Baird is Chief, Command & Logistics Branch, Dept of Tactics, USAAVNS. Maj Burnison is Chief, Research & Analysis Branch, Dept of Tactics, USAAVNS.

mediately before touchdown, relieving the fixed wing aircraft mentioned in the preceding paragraph. It is imperative that there be no break in this fire. It is preferable that the fires of the fixed wing aircraft be interrupted before delivering all the planned ordnance rather than allow the enemy time to catch his breath in the assault landing zone.

Escort helicopters will then deliver hover fire in the assault landing zone, delivering suppressive fire against known or likely enemy locations during the time required by the troops to off load and assume a fighting posture. This is the most important function of the escort helicopters, their reason for existence. They develop a base of fire, allowing the troops themselves to assume a fighting posture.

Throughout, it must be evident that armed fixed and rotary wing aircraft are compatible; both have well defined missions. The fixed wing aircraft cannot adequately perform the mission of the rotary wing in the assault landing zone; conversely, using the rotary wing aircraft for the missions defined as belonging to fixed wing does not utilize the unique features of the helicopter.

In the absence of fixed wing escort aircraft, rotary wing aircraft can be substituted to perform the fixed wing missions indicated here. This is not desirable, however, and such substitution should be made only in the total absence of such fixed wing escort.

The objective of suppressive fire can be explained by the old cliche, "If ducks had guns, there would be fewer duck hunters." Our intent, at maximum, is to prevent the enemy from firing on our formation; at minimum, it is to preclude his being able to deliver aimed fire.

Escort helicopters deliver final suppressive fire just before touchdown. Then they deliver hover fire in the LZ—the most important function they perform.

Lighter, smaller navigation system for Army Aviation to be tested

LORAN-D

A CONTRACT to provide models of a lighter, smaller navigation system for tests by the Army and Air Force has been awarded Sperry Gyroscope Company.

The joint tests will determine whether the new navigation system, known as Loran-D, can provide accurate position-fixing for both aircraft and ground vehicles.

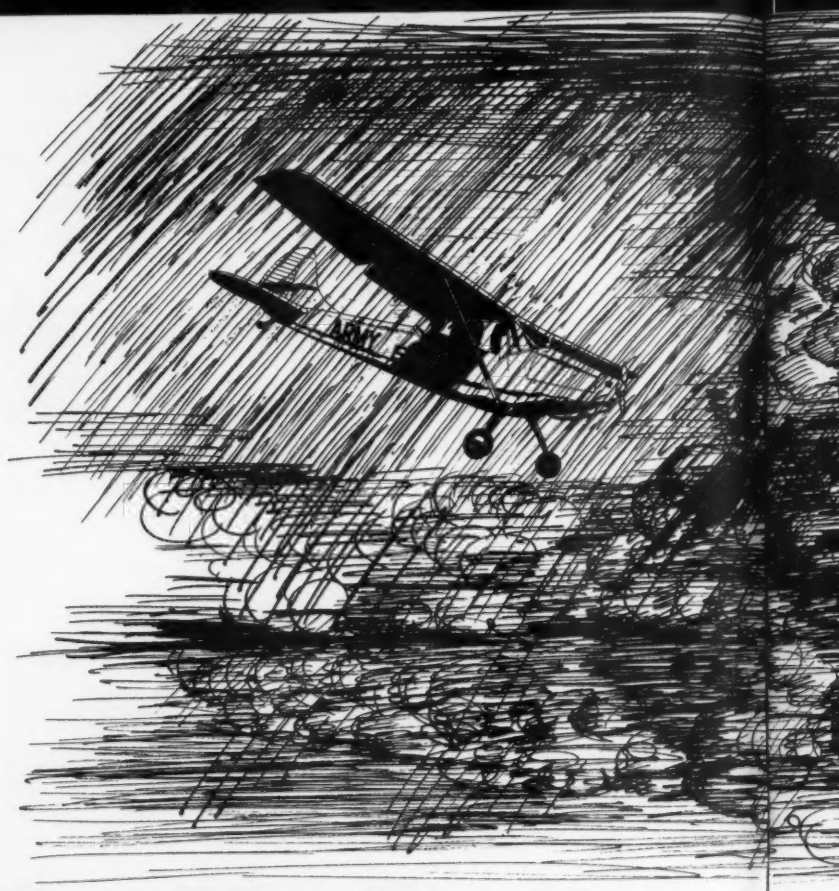
First phase of the testing will begin in December 1965 at Eglin AFB, Fla. Second phase will start at Army Electronics Proving Ground, Fort Huachuca, Ariz., in mid-1966. Air Force F-105s, Army fixed and rotary wing aircraft, M-60 tanks, and other vehicles will be equipped with Loran-D receivers.

Most of Florida and Arizona will be used for the tests. Transmitters and slave stations will be located at surveyed points on the ground. Their interlocking, circular wave pattern will provide airborne and ground receivers with information from which each individual operator can pinpoint his position in the pattern. From a map on which this pattern has been superimposed he can then locate himself on or over the ground.

Since Loran is widely used for commercial aircraft and marine navigation, both services believe it may serve as a tactical aid in locating and guiding units in battle—the same uniform system being used by all elements, both in the air and on the ground.

Captain Robert H. Stepp

If you pull a tour in Vietnam, you'll fly in marginal weather. Your regular communications network could go on the fritz.



Try FM Homing

A YOUNG ARMY Aviator, on his first solo mission in Vietnam, suddenly found himself low on fuel and caught in the worst rainshower he had ever experienced.

He was approximately 150 nm southwest of Saigon (his home base) and just south of his destination, the village of Ca Mau, an area heavily infested with Viet Cong. Because of his inexperience with Vietnam weather, he did not know that the rainshower would cover the whole delta, and suddenly realized that he could not land and refuel at Ca Mau as planned.

The aviator's first thought was to return to Saigon, but his fuel supply wouldn't allow this. His next alternate was Soc Trang, which he estimated to be approximately 40 nm northeast of his last known position. After flying northeasterly for what seemed an eternity, he was able to contact Soc Trang tower.

The tower operator informed him that Soc Trang was carrying 500 feet and 1/2 mile visibility in rain and that he could land, pilot's discretion in either direction.

After many attempts to tune in the Soc Trang nondirectional beacon, he realized that his ADF receiver was not functioning properly. By this time, he was down to 400 feet indicated and still couldn't see anything to his front except his windshield. He could see straight down, but couldn't locate the runway.

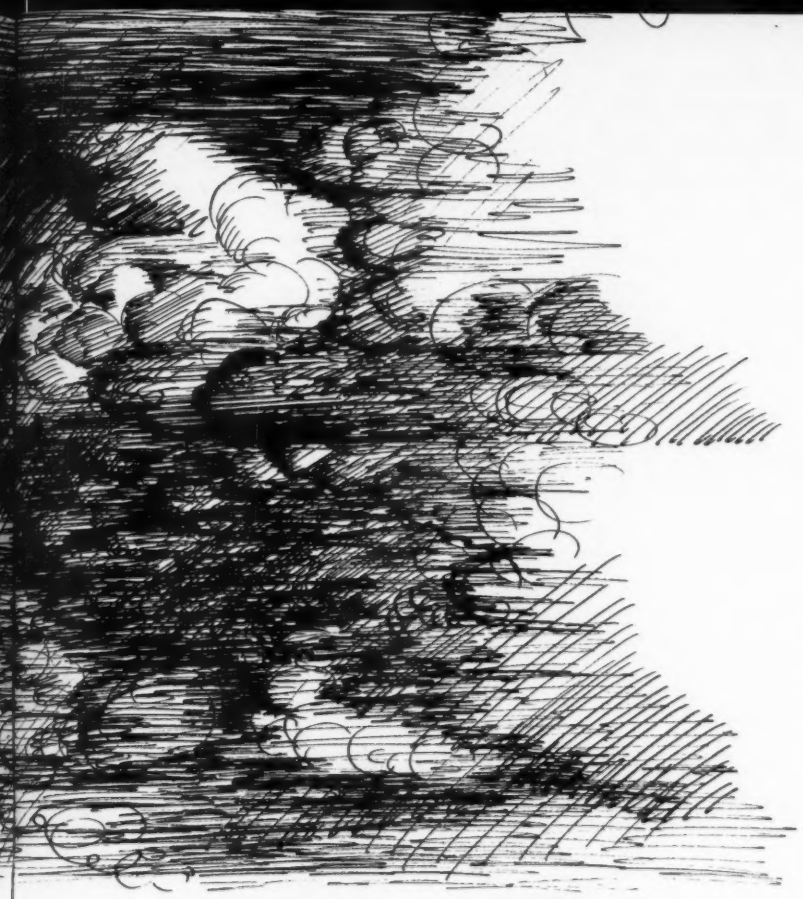
After flying around aimlessly for a short time, he contacted Soc Trang tower and asked for assistance. The tower informed him that all they had was an FM transmitter to which he could home.

He mentally started flipping pages in his memory book back to his flight school days. When he came to the right page, somewhere back in B phase, he found that he had never been too interested in FM homing and that he had learned just enough to pass the examination and work a problem on the field exercise. Luckily, this was enough to enable him to home to the transmitter at Soc Trang, locate the field, and land safely.

This aviator remembered. How about you? In the event you have forgotten, the following discussion will be helpful.

The ARA-31 homing antenna associated with the AN/ARC-44, FM radio, allows you to home to any FM transmitter, transmitting on a frequency within 24.0 to 49.0 megacycles.

Capt Stepp is an instructor in the Communications Branch, Special Subjects Division, Dept of Tactics, USAAVNS.



. . . It Satisfies

When attempting to home on a station which does not emit a continuous signal, it is necessary to establish voice contact with the station and request the operator to depress his transmitter switch for approximately 15 seconds with 10-second pauses between transmissions. Use the 15-second transmission periods to determine station direction and home. (Homing switch must be in the homing position during these periods.) The aviator and operator use the 10-second pauses to monitor or send voice transmissions. (Homing switch must be in the comm position during these periods.)

The operation of the ARA-31 homing antenna system is based upon the phase of the incoming signal as it reaches the ARA-31 antennas. If the signal reaches the left antenna first, the aviator will hear the Morse letter D (– . .). This indicates that the station is to the left. If the signal reaches the right antenna first, the aviator will hear the Morse letter U (. . –). This indicates the station is to the right. If the signal reaches both antennas at the same time, the aviator will hear the on-course, solid tone. This indicates the station is directly in front of or behind the aircraft.

FM homing can be quite simple if the following rules are used:

Rule 1: If the on-course signal is heard (solid tone), the aircraft must be turned (either right or left) until a U or D signal is heard. Then the aircraft must be turned in the direction the signal indicates until the on-course signal is heard again. The station will now be directly in front of the aircraft.

Rule 2: If the letter D is heard, the aircraft must be turned left until the on-course signal is heard. The station will now be directly in front of the aircraft.

Rule 3: If the letter U is heard, the aircraft must be turned right until the on-course signal is heard. The station will now be directly in front of the aircraft.

For successful homing and station passage indication, the pilot should, while homing on the station, make a 10° to 15° turn every 1 or 2 minutes (always in the same direction) to identify the signal. Then the aircraft is turned back on course, in the direction the signal indicates.

When a reversal of the signal is heard, the aircraft has passed the station and the pilot should continue the turn and start looking for the station.

Perhaps with this short description of FM homing, you too can be as successful as was the young aviator in the Republic of Vietnam.

Will this be Endsville? An airborne computing system, a passive nav system, EDNA, and other exotic equipment may someday help Army Aviators proceed to assault zones at 10-foot altitude!

Evolution

John B. Galipault

ATC CLEARS Alpha Leader with four to the FEBA via Guzzler's Gulch via Crescent Swamp via Dismal Forest, direct; maintain three zero feet. Right turn after liftoff; contact Bongo Control crossing FEBA, over . . ."

"Rog, ATC clears Alpha Leader . . . contact Bongo Control crossing FEBA . . ."

Mr. Galipault is principal researcher with the Dept of Aviation, Ohio State University.

"Roger, Alpha Leader, clearance correct; report out of five feet and reaching three zero feet."

Surely such an air traffic control clearance is unlikely in view of present operating procedures. However, imagine what en route and terminal operations would be like if pilots in nap-of-the-earth flight were subjected to normal stateside ATC procedures.

Let's ride along with Alpha Leader, a UH-1D, with four others being plugged into the traffic control system. Copilot Swinger had filed controlled VFR to the drop point some 20 miles behind the FEBA. He appears somewhat dissatisfied with the clearance altitude. The operations order called for a 20 foot cruise in view of the increased enemy ground fire and lack of terrain masking.

"Must be a lot of traffic this morning for Center to push us up out of the environment," remarked CWO Banger, the aircraft commander.

"Yes, Chief, it's really beginning to bug me. I can remember in Korea—we'd never have this kind of paperwork and lousy control. It sure was nice to go booming along through valleys and along ridges without worrying if somebody was at your altitude. It's getting so flying isn't fun anymore."

"You're so right. . . . Better give Center a call, Swinger; we're level at three zero."

Swinger makes his call and is advised by Center that radar shows a concentration of enemy weapons 12 o'clock, 1 mile, elevation unknown. Alpha Flight accepts a separation vector. This crisis past, Banger sighs, "Getting hung in one of those areas could ruin your whole day!"

A few minutes later . . . "Cen-

The operations order called for 20-foot cruise altitude

ter, Alpha Leader with four, Guzzler's Gulch Intersection, at 31, three zero, Crescent Swamp East at four zero, Crescent Swamp West next; go-ahead."

"Roger your progress, Alpha Leader, descend to two zero feet now. We have eastbound company aircraft your altitude."

"Okay, Center, Alpha Flight out of three zero for two zero, now."

Seconds later the pilots see a flight of three Charlie-Horse 47s closing fast overhead. Riding along, one cannot help but appreciate the efficiency of ATC. The greastest admiration and respect should be given to the airborne ATC units—particularly the manner in which their radar can pick out targets, both bogies and friendlies, in the environment. Someday it will be possible to give altitude information.

Swinger has already made his Dismal Forest position report. He suddenly presses both hands against his helmet to hear another flight talking to Center.

"Chief," said Swinger, "did you hear Delta Flight screaming for a lower altitude? I guess they were picking up a heavy load of rime ice at 50 feet. Center was going to put them VFR on top at 200 but found that one of the other servives has saturated all higher altitudes. Sounds like Delta will have to hold racetrack around Hill 65. Boy, I feel sorry for those fixed wing types sometimes. Getting in and out of those holding patterns can be rather sticky. Make an error in winddrift correction and it's 'junk piles on the hill'."

"Right," Banger responds, "better get out the approach plates for the drop zone. Give me my minima, field elevation, and missed approach. Better tune Pathfinder Blue for inbound steers. . . . There's the FEBA. Call Bongo Control and ask for approach clearance."

"Bongo Control, Alpha Leader with four, FEBA at 54, two zero; request clearance for approach."

"Understand Alpha Leader, the FEBA at 54, cleared for your approach, cruise two zero feet. Unable to give penetration radar vectors due to heavy traffic. No known traffic between you and drop zone. Present DZ weather is ceiling 50 feet broken, 200 feet overcast, environment visibility range 2,000 feet. If unable contact after DZ passage, call Center on 343.75 for missed approach."

"Roger, Bongo Control clears Alpha Flight. . ."

"Clearance correct Alpha Flight."

Banger checks his approach plate and calls all Alpha aircraft to close to 10 feet rotor separation with finger spread formation. The approach plate shows the marker beacon to be 900 meters from the DZ. Into his airborne computing system he punches the coordinates of the DZ and marker beacon.

Twenty seconds later the beacon light flashes and Banger gets the windscreen steering needle to the DZ. The display also shows the time-to-flare-out regardless to groundspeed in the approach.

"Brother," Swinger notes, "this passive nav system is the nuts. It sure takes the work out of the job. Better start your climb to 50 feet; and plate calls for a tall tree 300 meters from the DZ on course."

"OK. The tree is beginning to show on the EDNA (Environment Detection and Avoidance) display. DZ is 15 seconds away. Better start laying out some suppressive fire in 10 seconds," Banger orders.

The touchdown is clean and the flight completes the drop within 30 seconds of the programmed drop time.

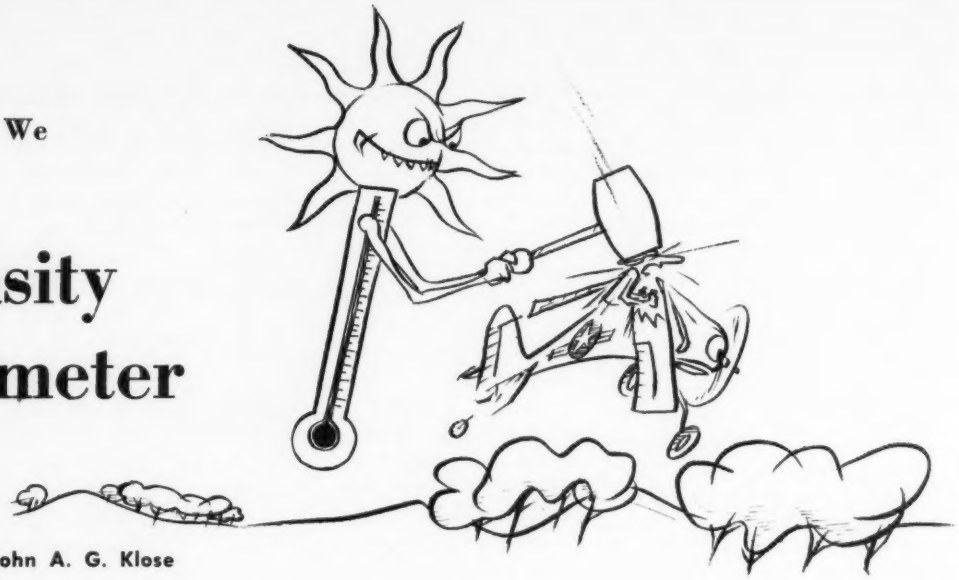
"I hope," Banger remarks, "the CO doesn't blow a seal because of the drop time error. We've got to find some better techniques for maintaining the schedule!"

"Swinger, give Bongo Control a call for a return clearance."

Such might be the commentary and events a few years from now. However, in the meantime, we can wonder how the air traffic control system might evolve and reach that point in sophistication.

Do We
or Don't We
Need A

Density Altimeter



Captain John A. G. Klose

IN THE PAST decade density altitude has become more and more an apparent factor in aviation safety. Before the "Jet Age," aviators knew that on hot days their airplanes were robbed of performance by heat. They also knew that their airplanes were robbed of performance by altitude. Therefore, when an aviator took off from such high places as Cheyenne, Wy., on a hot summer afternoon, he knew that his ability and the airplane's performance would be taxed beyond normal limits.

The effect of heat and altitude now is solved by relatively simple computations when you solve the algebraic formula for density altitude. TM 1-260, change 3, dated 21 November 1962, shows the simplified computation of density altitude (approximate), as a field expedient, as follows:

$DA = PA + 120\ (AT - ST)$

where

DA is density altitude

PA is pressure altitude

120 is a temperature correction constant

AT is actual temperature at the pressure altitude

ST is standard temperature for the pressure altitude

Without going through the mechanics of solving an example problem, I wish to pose this question to my fellow airmen: "Would you bet your life, and possibly the lives of your crew and passengers, on your computations?"

Let's analyze the formula $DA = PA + 120\ (AT - ST)$. PA, plus or minus 75 feet, can be determined simply by placing 29.92 in the Kollsman window of your aircraft altimeter. So your first unknown can be substituted in the formula with a probable error of from 1 to 150 feet.

First, let's find the actual temperature by looking at the free air temperature gauge on our aircraft, and substitute it in our formula with an accuracy of plus or minus 2° C. When multipled by a constant of 120 this could introduce an error of from 0 to 480 feet.

Second, let's determine the standard temperature for our pressure altitude. We know that the standard temperature at sea level is 15° C, we already know our pressure altitude, and we assume a lapse rate of 2° C per 1,000 feet. But WAIT: we don't know the standard temperature for the standard datum plane of 29.92" of Hg. We can only *assume* the standard datum plane to be at sea level. However, such is not always the case. The standard datum plane can and does vary as much as plus or minus 1,000 feet from sea level. So our third unknown is substituted in our formula.

Again, I ask you, "Would you bet your life on your computations?"

Let's compound our mathematical problem by computing the proposed density altitude of a landing site 4,280 feet above our departure site, based on our original computations. By *assuming* a temperature at our landing site we can compute a proposed density altitude as before.

Now, my fellow airmen, I ask you what the hell is density altitude anyway? Can we see it? Can we taste it? Can we feel it? The answer is NO! But your airplane can feel it.

Capt. Klose is assigned to USAREUR—Germany.

Density altitude is where your airplane thinks it is! Yes, your aircraft can sense density altitude better than you compute it!

The pilot knows where he is by reference to a map and his flight instruments. The airplane knows where it is with reference to the sea of air around it.

What has this to do with you betting your life? Well, basically, even with complete command of grocery store arithmetic, you can only make a calculated guess at density altitude.

The answer to this problem is a density altimeter, with a gauge on the panel to tell you density altitude continuously on the ground, in the air, and in any flight configuration.

Is there such an instrument? Yes, there is one! A density altimeter was submitted to the USAECOM as an unsolicited proposal in the interest of aviation safety in May 1963. This instrument weighs only 3 pounds installed, and will cost a minute fraction of the price of one utility helicopter.

Can we afford this low cost life insurance as opposed to the do-it-yourself kind we do with paper and pencil, with built in errors and assumptions?

You bet we can!

If adopted by the Army, the density altimeter would be a major contribution to general aviation safety, and truly would be an Army FIRST! Let's hope this "life insurance" appears in the field soon.

"Would you bet your life on a density altimeter?"

I would.

A Small Development Requirement for such a device was submitted by the U. S. Army Combat Developments Command Aviation Agency to higher headquarters for further action in September 1964.
—Editor

THE ARMY'S new M-5, 40 mm helicopter mounted weapon should be in the hands of the troops by this summer. Currently production testing and ground crew training programs are underway at Aberdeen Proving Ground, Md.

Developed by the U. S. Army Materiel Command for use on the UH-1 the M-5 is a flexible, electrically-driven, pilot or gunner operated subsystem employing the M-75, 40 mm grenade launcher mounted in the nose turret.

The M-5 is the first suppressive fire weapon completely developed by the Army specifically for use on a helicopter. The fully loaded system (150 rounds) weighs approximately 335.3 pounds and fires high explosive or inert grenades at a rate of 220 per minute at a maximum employable range of 1,750 meters.

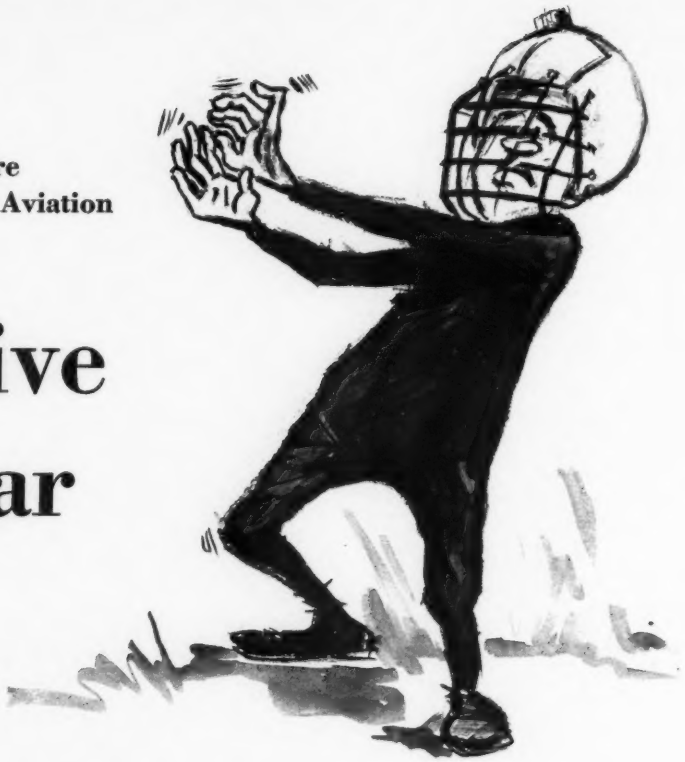
Ammunition is fed to the launcher through a flexible chuting from a storage box in the aircraft. The weapon is fired through conventional sighting and fire control elements which allow the gunner to elevate the nose turret 15°, depress it 35°, and traverse it 60° to the left and right. The turret also may be stowed in a predetermined position and fired as a fixed installation.

M-5 40 mm System Adds to Huey Punch

Past, present, and future developments of Army Aviation

Protective Headgear

Major George W. Aldridge, Jr.



IN THE LATE 1950s Army Aviation personnel and major league baseball players both began wearing protective headgear. The headgear proved an instant success and the number of serious head injuries incurred dropped sharply, both in the batter's box and in aircraft accidents.

Headgear worn by baseball players has continued to be satisfactory. But in 1961 in the Republic of Vietnam, Army Aviation personnel began encountering something significantly more potent than a pitched baseball or a roughing up in an aircraft accident—small arms and antiaircraft fire.

A new protective headgear was urgently needed, and the Army has come up with a nylon helmet which will offer protection from gunfire. It is expected to be available soon.

The first protective headgear for U. S. Army Aviation crew members was probably the "14-A"

COMBAT CREWMEN, 8TH AAF, WW II
STRUCK BY MISSILES IN HEAD

	Fatal	*Seriously Wounded*	*Uninjured*
Wearing no helmet	35.7%	64.3%	0
Wearing M-1 or M-3	33.8%	19.8%	46.4%
Wearing M-4	20.4%	15.2%	64.4%

Figure 1

helmet, developed in 1918. These helmets, made of manganese steel, received favorable test reports at Bolling Field, Washington, D. C., but came too late for use in World War I.

Between World War I and World War II, little development was performed in the area of protective headgear. But in 1942, it suddenly became obvious that many head injuries and deaths of combat flying personnel were avoidable. The M-1 helmet worn by the ground soldier was modified as a flying helmet and came into general use as the M-3 by the bomber commands. Later the M-3 was modified by cutting around the ears to accommodate head sets and decreasing its weight from 3 pounds, 20 ounces, to 2 pounds, 1 ounce. This helmet then became the M-4 or "Grow helmet." A more compact and more protective helmet, the T-8, was introduced later, but not in time for use in World War II.

Combat data available on the M-1, M-3, and M-4 flying helmets indicates a decline in casualties from head wounds as headgear was improved (see fig. 1).

According to Link and Coleman in *Medical Support of the AAF in World War II,* "fighter pilots preferred to use neither flak suits nor helmets for reasons that were felt to be adequate by command headquarters." When the Army and Air Force became separate services in 1947 Army Aviators also took this approach.

In the mid-fifties when Army Aviation took a sudden spurt in numbers of aircraft (principally helicopters) it became evident that some type of head protection was necessary. In 1958, the Army adopted a combat vehicular crewman's helmet (fig. 2) which was constructed of a 9-ply laminated ballistic nylon fabric and contained integrated communications equipment. To ascertain its suitability as a flight helmet, it was equipped with aircraft communications equipment and evaluated by the Continental Army Command. This helmet was found to be unsuitable as a flight helmet.

Consequently, at the direction of the Department of the Army staff, the Navy Flight helmet APH-5 (fig. 3) was evaluated and found acceptable for use even though it did not have ballistic resistance characteristics. It was adopted as an interim measure for head protection for Army flight personnel.

More than 40,000 APH-5s have been procured by the Army, and, as can be seen by figure 4, the payoff in saves has been great. This chart, compiled by the U. S. Army Board for Aviation Accident Research, represents a 2½-year period immediately following the adoption of the APH-5.

In 1961 Army forces entered the counterinsurgency actions in the Republic of Vietnam, and the need for ballistic protection again became important. A recent survey from the Surgeon General's Office of fatalities among helicopter crewmen in the Republic of Vietnam shows that head wounds account for about 50 percent of the gunshot wound-caused fatalities.

To meet this need for ballistic protection of the head as expeditiously as possible, the nylon helmet was developed. Made in the same configuration and weight as the APH-5, the shell is constructed of nylon fabric laminated with 40 percent modified resin (fig. 5). Officially it is called helmet, flying, protective (crash and fragmentation). Tests of this new helmet have established the following protective characteristics:

Figure 2

Maj Aldridge was Chief, Associated Equipment Branch, Materiel Division, Combat Developments Command Aviation Agency, Ft Rucker, Ala., when he wrote this article.

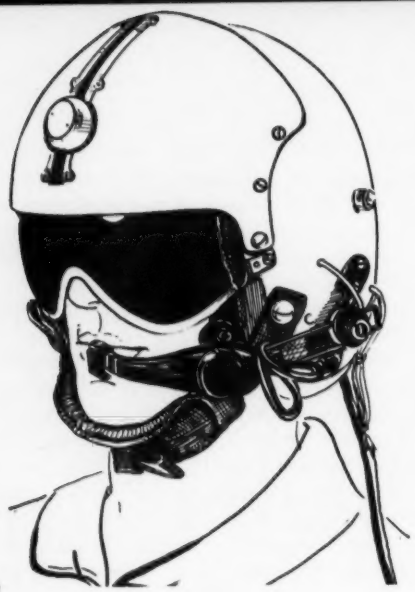


Figure 3

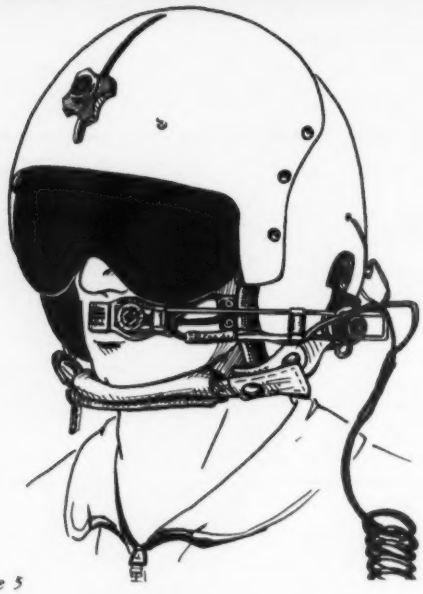


Figure 5

• The nylon helmet will resist penetration of a fragment traveling approximately 30 percent faster than would be stopped by the APH-5.

• When subjected to two successive impacts of 100 foot-pounds in the same area, the new helmet showed no evidence of bottoming. The maximum energy transferred to an instrumented head form was no more than 130 g's and 600 g's, respectively. This data shows that the nylon helmet will attenuate greater impact forces than the APH-5 to a level below the damage threshold of the brain. The damage threshold to the brain is generally considered to be 400 g's of accelerative force (fig. 6).

A comparison of the two helmets is shown in figure 7.

In conjunction with the helmet tests, a new carrying bag (fig. 8) was also tested and will be standardized along with the new helmet.

Figure 4

U. S. ARMY AVIATION ACCIDENT EXPERIENCE OF OCCUPANTS WEARING A HELMET 2½ YEAR PERIOD

	R/W	*F/W*	*TOTAL*
Helmet Prevented Head Injury	158	79	237
Helmet Prevented More Serious Head Injury	26	2	28
Helmet Failed To Prevent Fatal Head Injury	3	0	3
Helmet Structure Failed	3	2	5
Dislodged During Impact	21	1	22

Testing of the helmet has been completed by the U. S. Army Aviation Test Board and type classification action is underway. Priority of issue for this item will undoubtedly go to aviation units in the Republic of Vietnam.

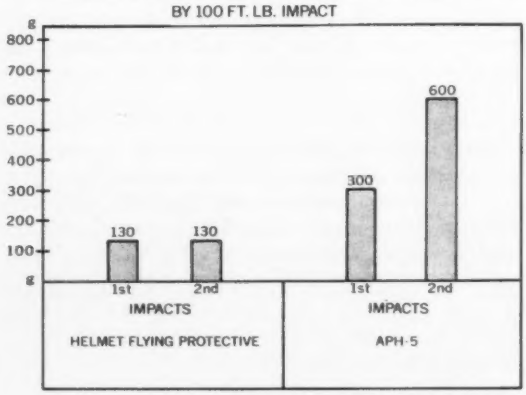
Prototypes of this new headgear and carrying bag have been furnished the USAF and USN for their consideration of possible tri-service standardization.

The latest Army effort in the development of headgear is now in the form of a proposed qualitative materiel requirement (QMR) for aircrewman protective headgear. This QMR is presently being staffed at Combat Developments Command headquarters and Department of the Army approval is anticipated in the near future.

This requirement calls for a protective headgear which will afford the aviation crew member with improved impact, visual, respiratory, acoustic, and ballistic penetration protection (fig. 9). To obtain

Figure 6

G FORCES IMPARTED TO AN INSTRUMENTED HEAD BY 100 FT. LB. IMPACT



COMPARISON OF APH-5 AND HELMET, FLYING PROTECTIVE

	APH-5	*Helmet, Flying Protective*
Cost	Same	
Weight	Same	
Comfort	Same	
Ballistic Protection (V50 Limit) *	800 fps	1050 fps
Crash Protection		+40%

*This is the impact velocity that a specified fragment simulator will have a 50% probability of penetrating a target.

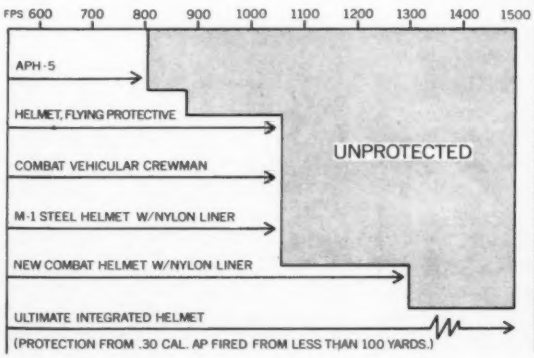
Figure 7

Figure 8

this increased protection, a simultaneous development of all characteristics, components, and concepts is essential. Recent advances in lightweight armor materials, particularly in ceramics, indicates that protection furnished by this item should be far superior to present headgear. It is the Army's hope that this item will be available in FY 1968.

Figure 9

BALLISTIC PROTECTION COMPARISON OF U. S. ARMY HEADGEAR (V50 LIMIT)



From the Flight Surgeon

Let Up On The Light Up

TO IRRITATE your eyes, impair your flight vision and depth perception, and reduce your altitude tolerance, take small doses of carbon monoxide. How? It's easy—just smoke! The serious effects on your system increase with dosage.

Unfortunately most pilots do not recognize that tobacco acts in a way similar to alcohol, as far as vision is concerned. Tobacco also reduces your altitude tolerance, partly by cutting down on your supply of oxygen and partly by increasing the rate at which your body uses oxygen.

The carbon monoxide which results from the incomplete combustion of tobacco is the very same gas that comes from the engine.

Incomplete burning of tobacco puts a small percentage of carbon monoxide in the smoke and whether you inhale or not, the carbon monoxide is absorbed by the blood stream in place of oxygen. If you do inhale, you simply make things easier for the carbon monoxide. When the blood is loaded with carbon monoxide, any oxygen trying to get in finds all the parking places occupied, and so proceeds blithely on its way.

Continued on page 32

UH-1 Collective Bounce

" . . . the savage and violent nature of the condition can't be appreciated."

Captain Edgar A. Westlake

STUDENT X rolled out on final approach for a basic autorotation. He bottomed pitch and rolled throttle to flight idle. The helicopter immediately entered into a violent, bouncing condition. The first thought was that we had lost something in the control system. For a split second, I was paralyzed. Then I took the controls, rolled on full throttle and applied pitch. The bouncing immediately stopped."

So reads one of many statements obtained from UH-1 instructor pilots who have encountered "collective bounce."

One wonders why more emphasis is not placed on this subject, not only during transition periods but also in the —10. The answer appears to be that collective bounce occurs but once to an aviator and from that point on he flies the helicopter to avoid this condition.

Through daily contact with approximately 50 UH-1 instructor pilots, some very interesting points regarding this subject have been established. If one has never experienced *true* collective bounce, the savage and violent nature of the condition cannot be factually

Pilots estimate the fuselage bounces 6 feet above and below the flight path plane

appreciated. Perhaps the statement of one of the more senior instructor pilots (approximately 18,000 flight hours with over 8,000 in helicopters) can emphasize it, "It was the second time since I started flying that I was just plain scared."

On the other side of the ledger, consider the less experienced instructor who continually insisted that statements concerning the bounce were exaggerated. His attitude was colored with skepticism throughout: "I demonstrate that by jiggling pitch whenever I find a student flying with little or no collective friction."

Fortunately or unfortunately as you may choose, this instructor while tooling the blue one day serenely "jiggled" the pitch and found himself rudely subjected to the true spasms of collective bounce. You may be assured he is now an avid believer and in addition studiously avoids "jiggling the pitch."

Collective bounce has been described verbally in many varied and colorful ways. Basically, however, it appears that the main consideration is the intensity or abruptness of vertical movement of the fuselage. All personnel flying helicopters have experienced some variation of a 1-1 vertical vibration. Those experiencing the more severe types have noted that the fuselage is actually bouncing up and down from the flight path plane. The more severe the 1-1, the more severe the bounce effect.

When true collective bounce is encountered it is almost identical to the 1-1 vertical vibration, with the exception that the vibration develops to a severe, violent, full bounce effect. Some pilots estimate the fuselage bounces 6 feet above and below the normal flight path plane. Instruments become a blur. A loose safety belt aggravates the situation in that the pilot is subjected to additional stress forces.

The collective pitch can be observed moving up and down in rhythm with the bounce of the fuselage. To stop collective bounce by manual force only, i.e., trying to stop the collective pitch from movement, is next to impossible once it is well established. Control of the helicopter on the straight and level is possible; however, as the bounce continues the pilot appears to increasingly lose perception. It can readily be seen that getting out of the situation as soon as possible is necessary.

Another major consideration is the high load forces imposed on blades, rotor, hub, mast, transmission, mountings, etc. Not being an aeronautical engineer and having no —10 reference to the phenomenon results in a certain amount of guesswork, but it is only logical to presume that most of these components have been subjected to or have exceeded the maximum allowable g force.

A survey indicated the majority of bounces occurred during entry into autorotation. Second, occurrences developed during a steep 180° turn after entering autorotation. Last, some were induced manually—i.e., by "jiggling" the pitch or with abrupt pitch power increases or decreases. At least 70 percent of the personnel contacted verified that one or more of the following conditions were present before encountering collective bounce:

Little or no collective pitch friction applied.

An imperceptible to a positive 1-1 vertical vibration present at some flight phase (hovering, climbing, cruise or descending).

Preponderance of craft involved were of the 1958 series with some 1959 models noted.

Based on these conditions, certain procedures to help prevent collective bounce can be determined and practiced.

• Be certain collective pitch friction is preloaded properly (4-6 lbs). Some resistance should be felt when actuating collective, even though friction lock is knurled off completely. (When checking any model, if there appears to be no built-in collective friction, i.e., if pitch will not maintain a static position and falls or bleeds off, be sure you can adjust the friction lock to compensate. If you can't accomplish this, have fun—because you are a

---

Capt Westlake is Flight Commander, Helicopter Instrument Flying Course, Instrument Division, Dept of Rotary Wing Training, USAAVNS.

likely candidate for collective bounce!)

• Any craft with the slightest 1-1 vertical should be written up. If a 1-1 vertical or lateral is detectable at a hover it will usually show up more positively during a climb condition or during acceleration to cruise.

Only one or two cases have been reported involving UH-1B helicopters; however, it is interesting to note that these were fairly high time ex-gunnery helicopters. So, we may anticipate that as the collective friction device deteriorates with age, more bounce cases may appear among these and later models.

How can we stop the bounce once it is started? First, remember that the longer sustained, the more difficult it is to stop. In nearly all cases where the pilot instantly applied the opposite action of that originally initiated the bounce disappeared (eliminating, of course, "jiggling the pitch"!).

It should be remembered that if collective bounce becomes well established, keeping the left hand on the collective pitch and trying to stop the bouncing with pure muscle will be next to impossible. In all probability this will only increase the bounce. Therefore, the pilot should slide his hand down to the friction lock and tighten the lock as firmly and as rapidly as possible. Should this fail to stop the bouncing, reach up with the left hand and turn off the servo switch. The shock of the control linkages going to direct mechanical action will break up the bounce rhythm. (Nearly all IPs felt this would be a "last ditch" action due to the extreme load forces imposed on the system at this time.)

Not all UH-1 aviators have or will encounter collective bounce. However, it can happen and should be anticipated. Knowing what is occurring and having the knowledge mentally stored away to correct the situation will ensure a recovery from the situation with a minimum of delay.

A RECENT FATAL accident of a YUH-1B was caused by noncompliance with MWO 55-1520-211-34/22 for modification of the main rotor blade trim tabs. Failure to comply with this MWO resulted in the loss of one trim tab which induced severe vertical vibrations and "collective bounce." The latest AVCOM figures show that this MWO has been complied with and reported for approximately 15 percent of affected aircraft. All units are urged to *comply and report* this modification.

Due to the length and weight of the collective pitch control lever, response to vertical vibrations of 5 CPS is predominant. Consequently, any (5 CPS) excitation induced by the helicopter or the pilot will cause the collective pitch lever to respond as "bounce."

Incorporated in the collective control is a friction device which allows the pilot to adjust desired friction; however, this device should be preadjusted so that a minimum friction value of 4 to 6 pounds is present even though the knurled adjustment device is at minimum setting. This minimum friction is "built in" and should always be present.

TM 55-1520-211-34 contains instructions for checking and/or adjustment of the built-in friction on the collective pitch control lever. TM 55-1520-211-10 does not contain information on collective bounce. Until the –10 is revised the following procedures are recommended for collective bounce prevention:

Ensure that an adequate amount (4 to 6 pounds) of collective pitch friction is applied at all times.

If collective bounce is experienced it can, in most instances, be stopped by turning off the hydraulic control switch. This action will change the vibration frequency of the entire system and induce a tremendous amount of additional collective friction. This change of frequency and added collective friction will dampen out the collective bounce.

—USABAAR Weekly Summary, 15-21 March 1965

It is dangerous to fly with traces of alcohol in your system.

Bottle to Throttle

Captain George W. Ingraham

IS ALCOHOL a problem in flying? The Naval Medical Newsletter for August 1964 (NavMed, p 639 vol. 44) reports that alcohol was a factor in 35 percent of all *fatal* general aviation accidents during the past calendar year. Post-mortem examinations showed an average blood alcohol of 145 milligrams per 100 cubic centimeters of blood.

Capt Ingraham is with the Office of the Flight Surgeon, U. S. Army Dispensary, Presidio of San Francisco, Calif.

What does this mean? In experimental conditions at what must have been the world's happiest laboratory, it was found to be very difficult to relate the amount of alcohol in the blood (or in some cases the amount of blood in the alcohol) with the degree of impairment. As a guide line, however, the figure of 150 mg per 100 cc is generally accepted as the level making a man unfit to drive an automobile. This figure is widely used as a cut-off score by police departments who test the blood for alcohol in the case of a suspected drunken driver.

In the case of flying, where we have added responsibilities for maneuver, higher speeds, communication, navigation, wind, density altitude and so on, a very high level of performance is required, and almost no alcohol can be tolerated in the blood. An added danger factor is that the effects of alcohol are greatly increased by altitude. One drink at sea level may have the effect of three at 10,000 feet (any airline stewardess will confirm this observation). For safety, therefore, THERE SHOULD BE AS MUCH ALCOHOL IN YOUR BLOOD AS THERE IS MOLASSES IN YOUR FUEL—and we all know that figure.

The problem is not the aviator who drains his glass of beer, picks his helmet up from the bar, strides through the swinging doors, and takes off. We all know better than that—and so did most of the general aviation pilots in the survey quoted earlier. The problem sneaks up on you, perhaps like this: An aviator has a drink before dinner (or two, if it's happy hour) and perhaps a glass of wine with dinner, then perhaps a small glass of brandy or a cordial afterwards. This can easily happen to you at a formal "must" the night before a flight. Or consider the case of the man watching a ball game or the late show until 0030 hours. You have to have something to wash those peanuts down, and pop tops are the most fun since the hula hoop.

These two men—the dinner guest and the television watcher—have both been drinking in moderation. Neither has been high, although delicate tests would show a loss of coordination and judgment. They both go to bed and wake up feeling well—and they both have detectable amounts of alcohol in their blood when they take off at 0800!

The gimmick here is a simple fact of biochemistry as concrete and unalterable as the performance figures on any of the hardware we fly. It is simply this: YOUR BODY REQUIRES ABOUT 3 HOURS TO GET RID OF 1 OUNCE OF ALCOHOL. You cannot alter this figure by taking any pill, by any trick of eating before or after, or by any amount of sleep or coffee, any more than a 45° angle of attack will win you long life and greater lift. You simply are not built that way.

"Hold on, now," the boys in the back will reply. "I know that if I eat a meal while I am drinking, I never get high, but if I drink on an empty stomach, I have to watch it pretty closely." True enough. But this fact relates only to the *concentration of alcohol in your blood;* it has nothing to do with the *rate at which alcohol is cleared.*

Look at the curves in figure 1. Curve A represents the blood alcohol of a man who drinks 4 beers on an empty stomach; curve B shows the same for a man who drinks 4 beers with a meal. The first man gets a higher concentration in his blood, since he absorbs his beer rapidly (the stomach, having

The Federal Aviation Agency is becoming increasingly concerned over the problem of aviators flying while under the influence of alcohol.

According to a story in the *Atlanta Journal* [Nov 7, 1964] by Robert J. Serling, United Press International, intoxication is no minor problem among private pilots. Statistics compiled since 1957 by the FAA have caused the agency to take a close look at the role of alcohol in general aviation (non-airline flying) accidents.

It was found that in 1963 more than 150 pilots and several hundred passengers were killed as the direct result of flying while drunk. A study of 477 fatal general aviation accidents, in which 899 pilots and passengers lost their lives, showed alcohol as a direct or indirect factor in more than one-third of the accidents.

FAA figures show that experienced pilots can get into just as much trouble from drinking as rookies. The agency's accident study did show that pilots with less than 300 hours flight time accounted for more accidents in which drinking played a role. But the same study indicated that veteran pilots tend to be overconfident about their ability to handle a plane after a few drinks.

Pilot ability, according to Mr. Serling, can be affected by only one drink. It takes just one drink to raise the blood-alcohol percentage as high as .05 percent, which is the medical threshold of intoxication. Add the affect of altitude to the alcohol and a pilot in most cases will have stepped over the threshold.

Federal regulations prohibit airline pilots from taking even a single beer at least 24 hours before a flight. The rule stems from medical findings that the average man recovers from alcohol only half as quickly as he can get drunk. For example, eight drinks consumed in 4 hours would require 8 hours for recovery.

nothing else to do, passes the alcohol right along to the blood), and will probably feel the effects, while the second man, whose stomach is slowed up by the food, is a little slower. Notice, however, the important point: *it takes both men the same time to become completely free of alcohol,* since they both absorb it faster than it can be cleared.

It is this last delightful fact, incidentally, which makes alcohol "work." If this were not so there could never be more than a trace of alcohol in the blood, which would make it a poor beverage indeed to relax with! In fact, we would probably be using 20-year-old Scotch to wash parts with.

There will be occasions when you wish to bend the elbow and yet know that you must fly the next day. How do you know how much you may safely consume? How long must you wait before flying if you have had a drink? Is there anything you can do, should an emergency arise, which will "clean you out" and allow you to fly safely?

The answer to the last question is, of course, NO. That's probably the most straightforward answer a medic will ever give you, so pay attention! As to the first two questions, the answer is fairly simple. You know that it takes 3 hours to clear an ounce of alcohol. You know about how much alcohol is in a given drink. You therefore grab your slide rule and T-square and come up with something like the curve in figure 2. Since no two drinks ever have exactly the same amount of alcohol, and there are myriad brands and proofs, these curves are an approximation. To be really accurate, you would need a different curve for every brand in the bartender's arsenal.

It's easy to use the graph. If you know how long you have before flying, look up the time in hours and read the number of drinks you are allowed from the other scale. On the other hand, if you are at the club and are called to the flight line, simply reverse the procedure to find out how long you must wait before firing up. For safety's sake, round off to the lower number of drinks and the higher number of hours.

I have already mentioned that the curves are approximate, and I should probably add a disclaimer to the effect that they have absolutely no official standing. The important points to remember when dealing with alcohol and flying are these:

- An amount of alcohol which would produce no effect at sea level can kill you at 10,000 feet, by ruining your judgment and coordination.
- Therefore, there should be absolutely no alcohol in your blood when you fly.
- You cannot possibly clear more than 1 ounce of alcohol every 3 hours, *no matter what you do.* It makes no difference whether you feel the effects or not, whether you eat or not, whether you drink coffee by the hatful—YOU NEED 3 HOURS TO CLEAR 1 OUNCE OF ALCOHOL.

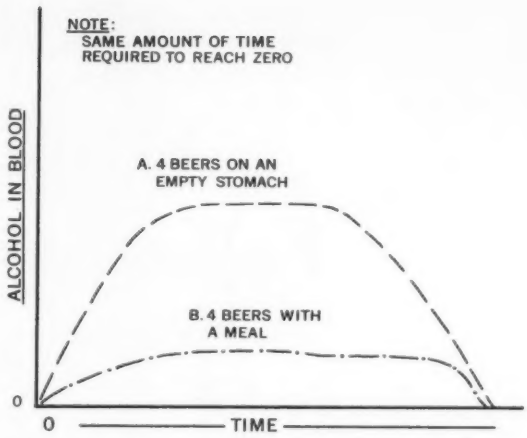
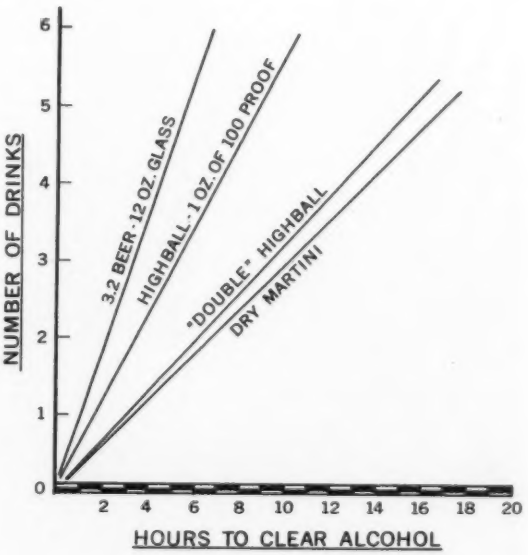


Figure 1

How dangerous is it to fly with traces of alcohol in your blood in case you decide to take a chance? In the general aviation accidents mentioned earlier, the average duration of the flights from takeoff to writeoff was 18 minutes.

Figure 2



You're never out of ground contact on air missions in RVN

Flight Following System

AN AVIATION Operating Detachment (AOD) of the U. S. Army Support Command here has been performing a little known task that affects nearly every pilot and crewman who flies in Vietnam.

The AOD operates a flight following radio monitor system throughout the Republic of Vietnam that ensures accurate knowledge of the location of all friendly aircraft in flight.

FOC is located in one of three specially designed vans and is normally manned by a crew of four

The need for immediate rescue of downed crews in a hostile environment and in a country lacking in effective road and communications nets is obvious. But knowledge of the troubled craft's location is a big hurdle in making the search and rescue attempt. This hurdle was made when the Support Command initiated a study to establish an effective nation-wide flight following system.

Taking advantage of experience gained in flight following already being done by the individual aviation units in Vietnam, the project effected not only a centralized monitoring system but a standardization of the many flight following procedures as well.

The outgrowth of the study was the Army flight operation system (AFOS) which provides continuous air-to-ground and ground-to-ground communications capable of 24-hour command control of all Army aircraft operating tactically in the Republic. The system can also assist USAF, VNAF and civil aviation in flight following.

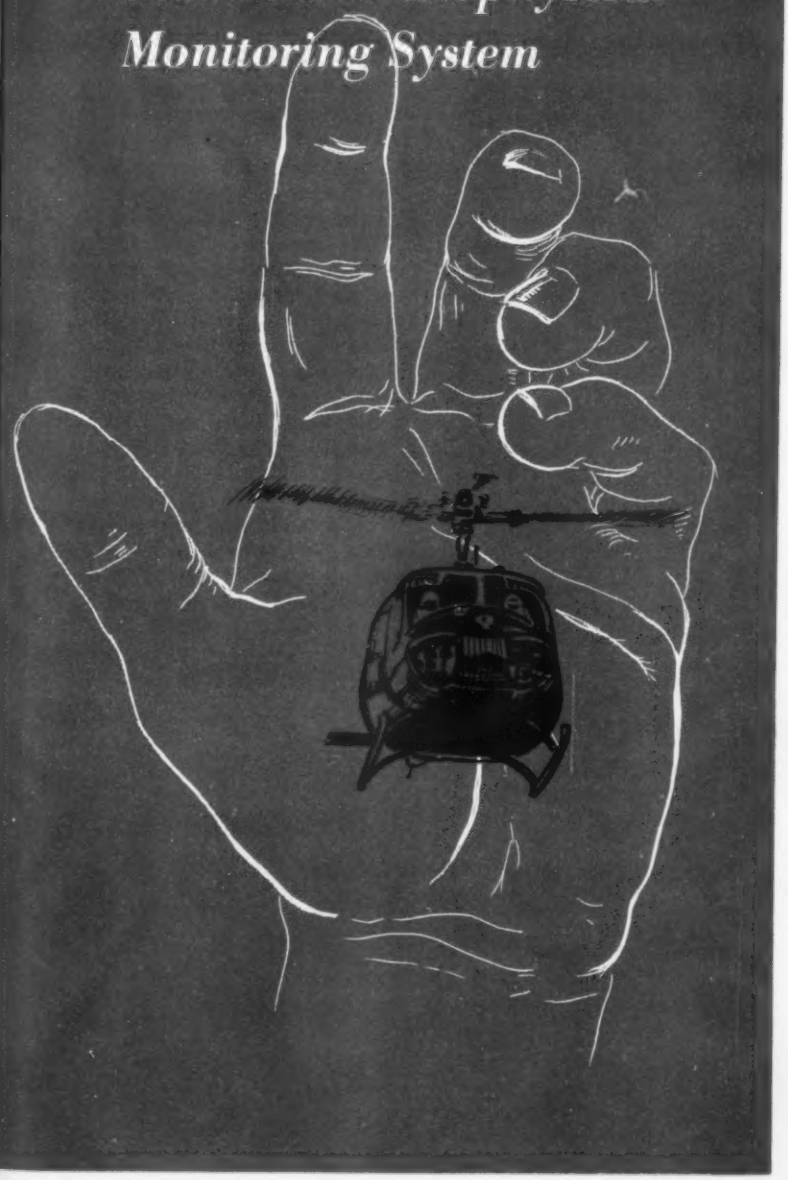
Today radio relay stations are scattered from locations near the 17th parallel in the north to the outposts in the Delta to the south. Three flight operations centers (FOC) working in Vietnamese Army Corps tactical operations centers (TOC) are strategically positioned.

Operated by members of the AOD and augmented by air traffic control personnel from all aviation units in the Support Command, these radio relay stations maintain continuous air-to-ground radio contact with all Army aircraft in their sector. Once a plane reports trouble or fails to report as scheduled, the FOC alerts the nearest unit as to the aircraft's last known location and destination. Should aircraft not be available in the vicinity of the downed aircraft, the FOC notifies USAF search and rescue operations and scrambles other aircraft kept on standby for just such emergencies.

Typical of the effectiveness of the command control system is a recent incident in which a U.S. Air Force Skyraider was downed by Viet Cong fire on the banks of the Bassac River near the small delta village of Ap Luong Diem, deep in communist-infested Vinh Binh Province.

The pilot involved broadcast a radio distress signal giving his approximate location. The Delta FOC monitored the call and scrambled Army helicopters near the crash scene. Twelve minutes after the pilot made his call, the AOD had him picked up. Seventeen minutes after the call, the pilot was safely deposited at a secure airfield.

Army Aviation's Latest Research Tool – A Biomedical-Biophysical Monitoring System



A Helping Hand

William H. Smith

REMEMBER YOUR first solo? Remember how your pulse quickened, your breathing increased, your temperature rose? Remember that funny sickening feeling in the pit of your stomach when you pushed the throttle forward for that very first takeoff?

Well, all of these feelings are body reactions to the strain you are under. How much do these reactions affect your ability to pilot an aircraft or affect your health in any way? The Army would like to answer this question, but before it can it needs to acquire more data about physiological functions during such flight profiles as solo. These physiological functions include such things as the temperature of the skin, the impulses from the brain

Front and rear views of mobile telemetry equipment

BOOT CONTAINS ELECTRODE AND SENSORING DEVICE

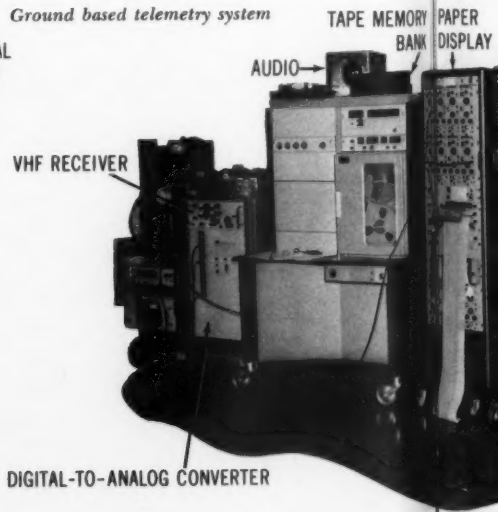
(electroensephalographic recordings) and the pressures imposed upon the body at the time.

To get this information, the specifications for biomedical-biophysical monitoring system were developed by the Aeromedical Research Unit, Fort Rucker, Ala. This system is similar to, but senses more functions than the telemetering systems employed in the space flights by NASA. Basically it has the capability to sense the information, process the data and make it available to the ground while the aviator is flying solo many miles away.

Telemetering is a system of picking up certain readings and measured information at one location and transmitting it to another. It is used in situations where it is dangerous, impossible, or impractical for the technician who reads the information to be physically present.

As an example, the Aeromedical Research Unit recently made an electrocardiogram (EKG) of one of its flight surgeons while he was in an aircraft several thousand feet above Fort Rucker. The results of the EKG were as good as

Ground based telemetry system

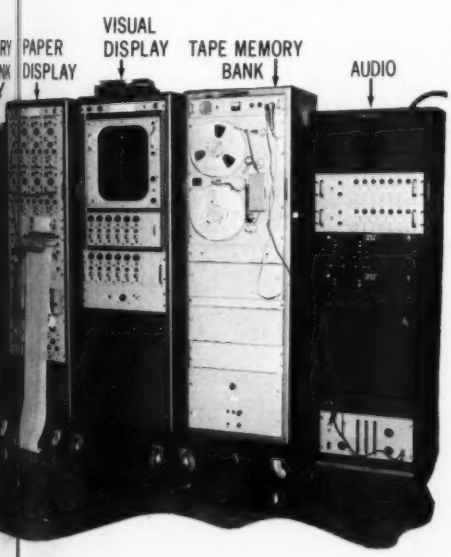


if it had been taken on the ground with conventional equipment.

The mobile part of the telemetry system is a series of electrodes which connect directly to the body of the individual being studied. These in turn connect to a belt harness containing a series of signal conditioners and a transmitter, each about the size of a pocket radio. They code the impulses gathered by the electrodes and transmit them to the receiver in the Aeromedical Research laboratory.

In the research lab, the signals are picked up by the receiver and decoded. They are then put on magnetic tape for permanent retention. In addition to the tape, the telemetering system can show the impulses visually on a scope or duplicate them on a pen-recorder. This can be done while the experiment is being conducted or later by rerunning the magnetic tape back through the machine.

The research unit's telemetry system will be used to observe the physiological actions of Army Aviators when they are flying alone, parachutists after they have jumped, and other personnel under situations of stress. The equipment will allow the research unit to study aviation personnel in action, investigate the causes of accidents under special conditions, study the ability of the human body under stress conditions peculiar to Army Aviation, analyze the phenomenon of exhaustion, and discover the most suitable way to maintain the health of aviation personnel.



Flight surgeons can tell much about a patient by his looks. One of the drawbacks to the research unit's biomedical telemetering system is that medical officers monitoring the system won't be able to observe facial expressions of the subject. Suppose, for instance, the subject under study should black out for a second or two. The telemetering system may indicate this in many ways but visual proof is still very desirable. To complement their new equipment the unit plans to install a high speed camera to watch the subject and record his movements and expressions. The film can later be matched to the tape.

One of the first tests to be conducted by the research unit will be a study of stresses and strains imposed upon the body of a parachutist in free fall. The unit is anxious to discover what g forces and acceleration and deceleration forces parachutists receive. If the exact nature of these strains can be determined it may be possible to devise an improved method of jumping and landing that will reduce the number of injuries sustained.

There are other questions not directly associated with telemetry that also interest the research unit:

- Do stress and strain seriously reduce the aviator's capacity by adversely affecting his judgment, skill, or reaction time?
- Do noise levels in the cockpit and cabins of Army aircraft, especially when flying with doors and windows open, damage acoustic nerves?
- Do aircraft vibrations, when associated with buffeting and accelerations, overstimulate inner ear and sensitive body tissues and hasten fatigue and vertigo?
- Does hypoxia affect aviators in Army aircraft and if so to what extent?
- What effect does hypoglycemia have on aviators? What degree of hypoglycemia, when combined with other stress-inducing factors, affects an aviator's tolerance?
- Why does vertigo supposedly occur more frequently in helicopters than in fixed wing aircraft? What effect does the slowly revolving rotors, "flicker phenomena," have upon this increased vertigo?

In addition to studies related to these questions, all types of fatigue found in Army Aviation will be evaluated. Physical fatigue occurs as a result of excessive use of body tissues and organs. Skill fatigue results from the prolonged application at a skilled task. Static fatigue occurs when the subject is restricted in movement. All of these are problems in Army Aviation and the research unit wants to find out more of their effects.

Passengers on board Army aircraft won't be neglected by the Aeromedical Research Unit. The unit hopes to use its telemetering system to observe the reactions of patients to flying. Particular attention will be paid to heart patients and those with lung injuries.

Answers to many more questions will be sought by the Aeromedical Research Unit. In some cases, little or no work has been done on them and vital statistics are missing. With information the biomedical telemetering system can give, Army Aviation may increase its safety and reliability.

Low Level Location

Captain Thomas K. Phifer

DEMAND IS increasing for tactical low-level navigation at night and during periods of low visibility when landmarks and reference points become harder to pick up and recognize. The problem is even doubled when sophisticated navigational equipment such as radar, Decca, Doppler and the like is not available.

What then can we use to assure accuracy? No system or means gives 100 percent accuracy, but there are means that will put us close enough to our desired landing zone to make accurate low-level navigation feasible under adverse conditions. Anyone who has flown a troop or logistics lift over unfamiliar terrain at night when there is very little or no horizon and visibility is limited will agree, I'm sure, that positive pilotage navigation becomes a real problem. To be close enough to pick

Capt Phifer is with the 228th Aslt Spt Hel Bn (CH-47), Avn Gp, 11th Air Aslt Div, Ft Benning, Ga.

Figure 1

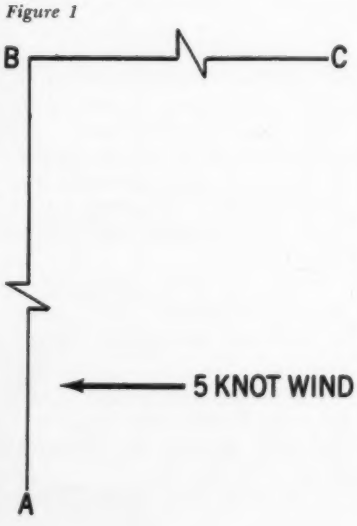
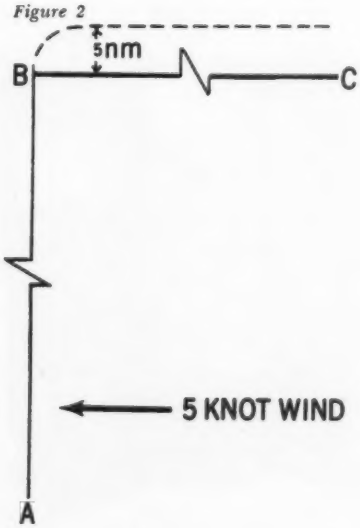


Figure 2



nof an LZ

up the RP (release point) lights is sometimes a matter of luck, and if the landing zone is any great distance away, it might even be more luck if it is found.

To illustrate the means suggested earlier let's take, for instance, a flight course with two legs to be flown from point A to point B to point C (fig. 1). At point B there is a 90° turn to the right. The distance between point A and point B is 35 nm and the distance between point B and C is 19 nm. The wind is from the right at 5 knots and the groundspeed after wind calculation will be 95 knots from point A to point B. Crossing point A at 95 knots and flying exactly 22 minutes should put the aircraft directly over point B, provided the proper wind correction has been held.

If the aviator begins a standard rate turn to the right at this time and rolls out on the new intended heading, he will be just a fraction over ½ nm to the left of his intended course, and no positive way to get back on course (fig. 2). The error encountered in the single 90° turn would still allow the aircraft to be within the error probable radius But if several more turns had been required to circumnavigate a terrain feature or hostile area, the error would have been greatly magnified, even though great flying skill and exact

Figure 3

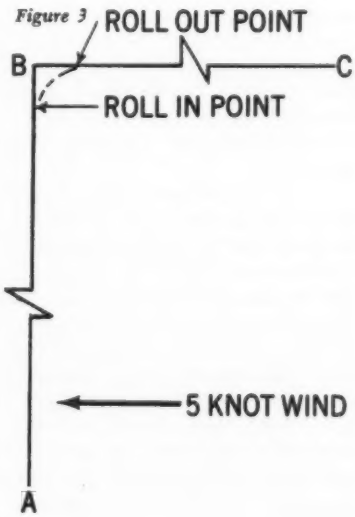
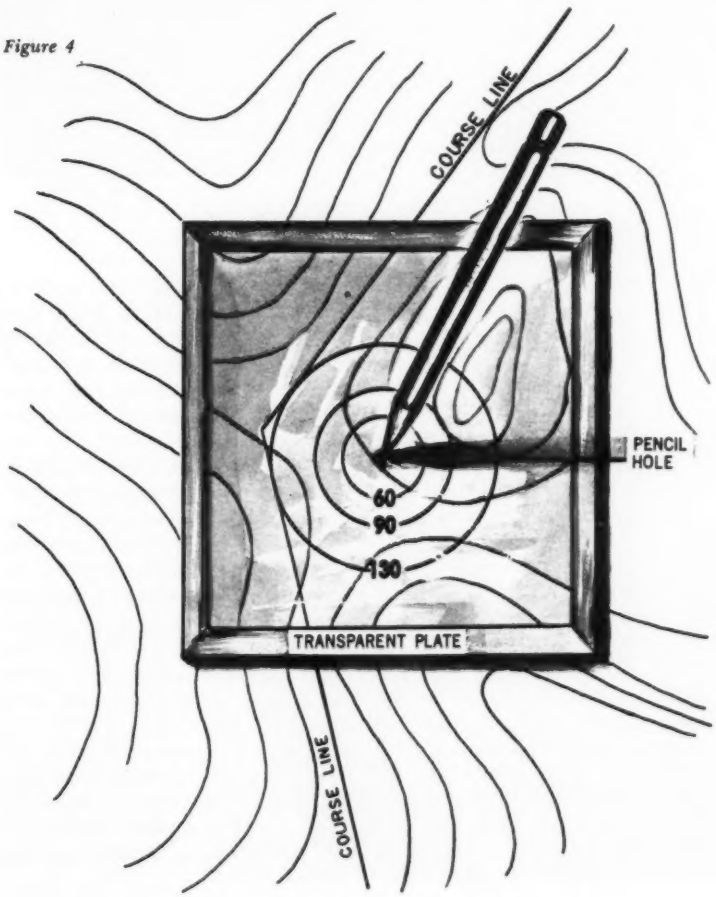


Figure 4



3° per second = standard rate turn.

Airspeed (IAS)	Circle Circumference	Standard Rate Turn Angle of bank	Diameter
60	2.0 nm	11°	.64 nm
65	2.16	11.5°	.69 nm
70	2.33	12°	.74 nm
75	2.5	12.5°	.79 nm
80	2.66	13°	.85 nm
85	2.83	13.5°	.90 nm
90	3.0	14°	.96 nm
95	3.16	14.5°	1.01 nm
100	3.33	15°	1.06 nm
105	3.5	15.5°	1.11 nm
110	3.66	16°	1.16 nm
115	3.83	16.5°	1.22 nm
120	4.0	17°	1.27 nm
125	4.16	17.5°	1.32 nm
130	4.33	18°	1.37 nm

1: 25,000
1: 50,000
1: 100,000
1: 250,000

Airspeed Error ± 3 knots = @ 10 nm =
20 nm =
30 nm =
40 nm =

Figure 5. Roll in and roll out scale

Straight Line Distance	Error Probable (Circular)
100 nm	2.5 nm
50 nm	1.5 nm
25 nm	.75 nm
15 nm	.40 nm
10 nm	.20 nm

For all distances above add —
.5 nm for 1 turn (90°)
1.0 nm for 2 turns (90°)
1.5 nm for 3 turns (90°)

Figure 6. This estimated error probable scale is suggested

calculation had been employed throughout the flight. If the radius of the turn is figured and the precise roll in point and roll out point is calculated, the off course error is greatly reduced (fig. 3).

To expedite figuring the roll in and roll out point a graph of circles drawn from map scale can be made on transparent material, using the scale on figure 5. (See fig. 4). This may be laid over a particular course with the desired airspeed circle placed on the inside of the turn and touching both courses. From this the roll in and roll out point may be determined.

The graph should have a hole in the center through which the point of a sharp pencil may be inserted to make a dot on the map. Then the distance from the pencil dot to the course is measured with a compass and the desired turns drawn, graphically portraying the desired turn. Wind is a factor to be dealt with by figuring the drift angle from reported winds and correcting for error when and if possible during the flight.

Once point C has been reached, how close can we expect the aviator to be to that exact location on the ground, provided he has used the suggested method? This depends upon the distance of flight covered and the number of changes in direction that were made. The error probable at the end of the flight is in direct relation to the distance and the number of changes of direction required. As the distance increases and the number of direction changes become more frequent, the radius of the error probable becomes larger.

In artillery and bombing an error probable is figured on the basis of a certain percentage long, a certain percentage short, and a certain percentage to either side of a target within a specified radius. The distance from the center of a release point that an aviator could be expected to be within after a given flight can be calculated in the same manner, provided certain facts are known, such as the distance to be traveled, the number of turns to be made, and our old variable, the wind.

For instance, if the circular error probable is 3/4 of a nm for 25 miles of straight line flight, then the release point must be recognizable at low level from at least 3/4 of a nm (fig. 6) in any direction for the aviator to locate it. If recognition is not possible, then some type of radio or visual signal must be used to pinpoint the location.

To be accurate the pilot must always fly by reference to instruments alone, for which instrument qualification would be essential. The copilot maintains visual reference, adjusts altitudes, and provides a crosscheck on position when ground reference is possible and position fix can be established. Pilot and copilot proficiency become very important in the success of a mission flown in this manner.

This article is adapted from the booklet "Leisure Time" published by The Equitable Life Assurance Society of the United States, New York, N. Y.

All Work and No Play May Make Jack — But Pity Poor Joe!

MAKING A LIVING — these words probably dominate more lives today than any combination in the English language. The pressures engendered in this frantic pace to provide more and better material advantages for our families take a fearful toll in mental and physical health. We see the results daily in the shattered lives around us.

Army Aviators are not immune to these pressures. Their way of "making a living" fortunately coincides with the military defense of our Nation. In fulfilling this task they train and work hard, particularly in times of cold war tensions and hot war stresses. Today many aviators are devoting their entire waking hours to their jobs. They have forgotten how to enjoy themselves. They think play is a waste of time, energy, and money, or is even selfish and positively sinful.

Enjoying leisure time is healthful, restful

These aviators are some of the best in the Army. They know how to fly; there's no doubt about it. And there's no doubt flying can be deeply satisfying. But it should never be regarded as the only important and interesting thing in life. Flying is work, and everyone needs some fun along with his work for true mental and physical health.

YOUR LEISURE IS NOT A LUXURY

To keep alive all you really need is food, clothing, and a place to sleep. But to live a full life you must also have a time for recreation. Leisure well spent gives you time to think, develop interest in things, and be creative as well as recreative. It relaxes tensions and improves your capacity for learning and for doing a better job no matter what your work may be.

To have a balanced personality, learn to work and stop working, to be active and be quiet, and to be content alone as well as with people. You must find time for solitude, for thinking, and for spiritual concerns. Only then can the inner man find fulfillment.

GOOD HEALTH IS A NECESSITY

To be a safe aviator you must be healthy. Good health is also a means toward a freer and fuller life. It's easier to be happy when you're full of energy than when you're worn out or full of aches and pains. Today we know that health is not a matter of physical condition alone; it is the well being of the whole man, made up of his many tangible and intangible parts, reflecting the physical, mental, and spiritual.

It's sort of a revolving circle—you enjoy leisure more when you are feeling healthy and you are healthier when you enjoy your leisure. You get into this circle by following these simple, sensible rules of good health:

- a well-balanced diet,
- proper amounts of exercise,
- sufficient rest (because you are busier as an aviator and family man you may find you need more rest than when you were a youngster still in school),
- a balanced schedule allowing for work and recreation.

COMMON SENSE DIET

Eating not only is necessary for existence, it can also be a delightful leisure activity. This kind of leisure, though, has a catch—overdo it and your health suffers.

The moral is to eat a sensible, varied, well-rounded diet. If you eat the wrong foods, you can be as fat as a hippopotamus and spend as much money on food as a millionaire and still be ill from near-starvation. Try to keep your weight around what it was when you were at the peak of physical condition (usually in your 20s), give or take 10 pounds.

Moderation in exercise is sensible

EXERCISE

Some aviators spend a lot of time doing calisthenics. This is fine if done regularly and not overdone. However a few popular myths about exercise need exposing:

- Exercise alone will not keep weight down. It will help, but it's no guarantee—and it can boomerang by increasing appetite.
- Hours and hours of doing backbends, lifting weights, and touching toes is not the only kind of exercise. Moderate exercise, like walking, is beneficial if done regularly. If you are not the athletic type, it is better to exercise moderately than to wear yourself out in violent workouts.
- If calisthenics is what you enjoy most, keep it up by all means. Most people will probably obtain more benefit from a recreative sports activity in which they participate with other people. Remember, though, moderation in exercise (as in most things) is sensible. As you get older you should gradually cut down on violent exercises. When you find yourself getting overly tired, that's the time to slow down.
- Don't overdo the "pals with your youngsters" idea. When you are 40 or 50 you can't keep up with those who are 20. If you want to live long and happily, act your age.

SLEEP

This is one commodity that most of us feel we never get enough of, and too often this is true. In the pace of daily life we often leave too little time for rest—or we become so tense from the pressures surrounding us that we suffer from insomnia. Yet sleep is one of the most vital cogs of a healthy life. Happily, sleep is the natural result of proper diet and exercise. In turn it provides a rested, happy individual eager to face the challenges of both work and play.

Try something new—broaden your interests

Use common sense about your diet

TOO FEW INTERESTS

Some aviators' interests are so narrowly specialized that they can think of only one thing to do in their leisure hours. If for some reason they can't do this, they are miserable. For instance, a "happy hour" enthusiast started gaining weight and was put on a diet—no drinks for a month. The poor elbow bender hardly lived through the month with nothing to do. Or take the "golf fiend" with a bad sprain. What a sad weekend with nothing but the wife, kids, and TV for entertainment.

You need more than one type of leisure time interest. Have you stopped growing, now that you're a grown-up? Or did you grow lopsided instead of up?

How long has it been since you've tried something new? If you're always doing the same thing, it's time to make an effort to find new things to do, to broaden your interests.

FAMILY LIFE CHALLENGES LEISURE

Family interests probably keep you very, very busy. Besides soldiering and flying you spend many hours nursing children through measles and mumps and battles and bumps. And the commissary run or quarters cleanup campaign takes other hours. Your leisure time seems to take care of itself—by

All Work and No Play

disappearing. So you think this talk about developing interests and having a balanced program of recreation doesn't apply.

Those children of yours will grow up and leave home. This will be about the same time you have your retirement parade.

Your home and your life will suddenly turn into a lonely, silent place. So you had better develop now some long-range interests that will give life continued meaning and happiness then.

CAN YOU PUT IT OFF?

Habits sneak up when you aren't looking, especially lazy habits. Is it really going to be easier to develop new interests when you are older and less energetic? An unused airplane gets rusty and useless; so do unused talents. Besides, some of the most satisfying hobbies are lifelong interests and take time to develop. They don't spring forth full-grown when you need them.

There are almost as many different hobbies in the world as there are people. But all of them involve at least one of these activities and can be done either alone or with other people:

- Doing something.
- Learning something.
- Making something.
- Collecting something.

Your taste may differ from others, so in picking your hobby be guided by our own interests. Don't feel that you have to join the herd. You might be proud of being the only collector of torque link assemblies from the forward landing gear of old HC-1Bs.

FOR DEEP AND LASTING HAPPINESS

Think of leisure as the exciting opportunity it really and truly is . . . the time that gives you a chance to develop as a free and complete person. Cherish your leisure. Use it as a true recreative experience—a time of renewal and refreshing from the frictions of life. You can never contribute your best to Army Aviation without a firm hold on mental and physical health.

Let Up on the Light Up

Continued from page 15

The fact that blood actually prefers carbon monoxide to oxygen and absorbs it 210 times as readily makes things worse. If you're a heavy smoker, you can get as high as 10 percent carbon monoxide blood saturation. It takes only 3 percent to cause measurable impairment of functions, such as vision and altitude tolerance.

With the 10 percent concentration possible by heavy smoking, you are halfway to the 20 percent stage. With 20 percent saturation you are in pretty bad shape, and might not be able to continue reasonably safe control of your aircraft because of throbbing headache, visual impairment, reduced power of concentration and muscular incoordination.

One of the insidious things about CO poisoning is that you are subject to sleepiness, reduced mental and physical powers and some loss of vision prior to any recognizable symptoms, such as headache.

If you have been smoking steadily, you have enough carbon monoxide in your blood so that at 10,000 feet altitude your body acts as though it were at an altitude of 14,000 or 16,000 feet. Your vision will be correspondingly affected.

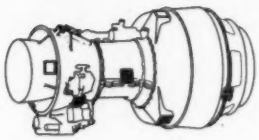
In fact, smoking just three cigarettes in a relatively short period just before takeoff will reduce your night vision as much as the effects of 8,000 feet of altitude. One cigarette results in a saturation of 1 to 1.5 percent of your hemoglobin with carbon monoxide instead of oxygen.

Once carbon monoxide enters the bloodstream it leaves very slowly, like alcohol. About half of it is still present at the end of 6 hours, and some may still be left at the end of 24 hours.

At the same time another product of smoking causes problems. Nicotine raises your requirements for oxygen by 10-15 percent. A further adverse effect of nicotine is its interference with your reactions. It also increases your nervous instability and tires your mental processes. Night vision is reduced, and your depth perception can really get knocked off center. A smoldering cigarette also produces ammonia which irritates the eyes.

The pilot who wants to fly at optimum efficiency and safety will try to reduce his smoking, especially just before flights, and most especially before night flights.

Low Power



Turbine Operation

Sam Baker
Predesign Engineer
Bell Helicopter Company

GAS TURBINES have made tremendous advances in the aircraft industry.

Being of a different type design is one of the great assets of turbines. Other assets include: freedom from reciprocating vibration experienced on other type engines, maximum economy at higher powers, minimum number of rotating parts, etc.

Gas turbine engine application with regard to power output is different. The power output is a function of turbine speed and the resultant amount of air that is passed through the engine compressor. At the higher powers response during acceleration is extremely rapid. However, when operating at lower powers considerably greater time is required to accelerate the compressor to the higher speeds required to pass more air through the engine.

Let us review the operation of the T53 free turbine engine installed in UH-1 helicopters.

The engine can be considered as two sections: the gas producer section, and the power turbine section.

The gas producer section consists basically of the compressor and the first-stage turbine furnishing the power required to rotate the compressor. The compressor has blades fixed on a spindle that impel air rearward in the same manner as a propeller by reason of their angle and airfoil contour. Between the compressor stages are rows of stator blades. They control the direction of air to each compressor rotor stage to obtain the maximum possible compressor blade efficiency.

After the air is compressed it passes through the combustion chamber where the fuel, which is introduced at this point, is burned. The hot gases then pass through the first-stage turbine wheel, causing it to rotate and in turn rotate the compressor. The N_1 tachometer indicates the speed of the gas producer in percent rpm.

The power turbine section consists of the second-stage turbine wheel, its interconnecting shaft and speed reducing gears, including the torque-meter section, in the front of the engine. This turbine converts the hot gases being forced through it into shaft horsepower.

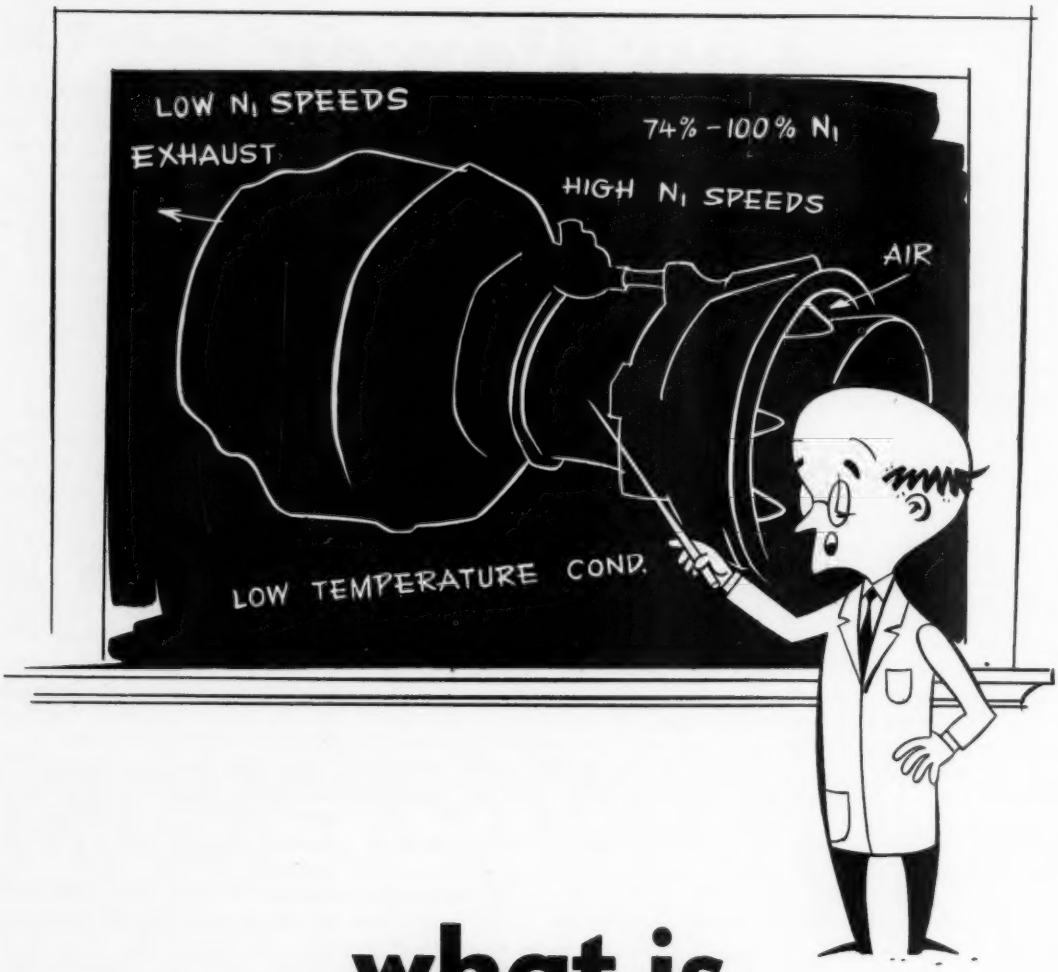
The amount of shaft horsepower that can be derived is proportional to the amount and velocity of the gases being forced through it. The N_2 tachometer indicates the output shaft speed of the power turbine in rpm.

As a result the amount of horsepower the engine is producing at any time can be controlled by the amount of gases the gas producer section of the engine is producing, and this is controlled by the speed at which the compressor is turning. It follows that if we want more power, we can get that power only as fast as the compressor can be accelerated. Therefore, the slower the compressor is turning, the slower it can be accelerated; the faster it is turning, the faster it can be accelerated.

If an attempt is made to accelerate the compressor too rapidly in the low power range, the result will be what is commonly called compressor stall or more correctly compressor surge.

Stalls vary in severity depending on whether the stall involves only a portion of a stage, several stages, or an entire compressor.

Continued on page 48



what is compressor stall?

Sam Baker
Predesign Engineer
Bell Helicopter Company

with us for many years, this phenomenon is still a mystery to many people

COMPRESSOR STALL is one of the problems involved in the operation of gas turbine engines.

The true nature and cause of compressor stall is often shrouded by the mass of theory surrounding the operation of the gas turbine engine.

The purpose of this article is to show just what compressor stall is, how it occurs, and what steps are taken to avoid it.

STALL

Everyone in aviation is familiar with the common phenomenon of airfoil stall. The fact that compressor stall and the stalling of an airfoil are basically the same is often overlooked.

The stall point of a fixed wing aircraft is affected by many conditions, such as g forces, air density, and airspeed. When stripped of outside influence, the point of stall is determined by one thing only—angle of attack. When the angle of attack is increased, the lift produced by the airfoil is increased up to a certain point. This point is known as the critical angle or angle of stall. When this angle is exceeded, the lift produced drops off sharply.

The cross-sectional area of a blade in an axial flow compressor is similar to the airfoils used on some fixed wing aircraft. Thus each blade obeys the same law of stall as explained above. It is the ability of the compressor blades to produce lift which gives the increase of pressure within the compressor section of a gas turbine engine. Note that like its fixed wing counterpart, the compressor blade has both an angle of attack and relative movement between the air mass and the airfoil.

When the fixed wing airfoil produces lift, it attempts to move within the air mass in the direction of lift. Since the compressor blade cannot move, the air mass is forced toward the rear of the compressor section of the engine. Because the area of the compressor duct through which the air mass must travel is gradually decreased, the pressure of the air must increase.

Within the compressor section of the engine, two things affect the angle of attack of the compressor blades: mass airflow through the compressor and the compressor rpm.

If rpm is increased without a corresponding increase in mass airflow or if airflow is decreased without a corresponding decrease in rpm, the effective angle of attack of the compressor blade will be increased. If this angle is increased beyond certain limits, stall will occur.

The effect of compressor stall on an airframe/powerplant combination differs from installation to installation.

The prolonged operation, under stall conditions, of a turbojet powerplant such as used in military fighters has been known to cause disintegration of the compressor spool and turbine sections with resultant damage to both airframe and powerplant. Generally speaking, compressor stall causes little or no damage to the turboprop/T53 combination.

Still another result may be seen in the UH-1B/T53 combination. In this case stall generally does no damage to the engine; however, damage to the airframe may be extreme. Here violent transient torsional loads from the engine are transmitted to the airframe, causing damage to such items as the main rotor, transmission, and tail rotor drive system.

Stalls vary in severity, depending on whether the stall involves only a portion of a stage, several stages, or an entire compressor. Incipient stall may produce roughness with or without the audible accompaniment of a rumble, drone, or similar noise. More pronounced stalls may produce noises varying in intensity from sounds similar to pistol shots to cannon fire and can be quite disconcerting.

If compressor stall is encountered, the best way to deal with it is to decrease the throttle setting (roll off on the twist grip). Maintenance personnel should be notified and given details of the occurrence in order to determine the extent of the inspection.

CAUSES OF COMPRESSOR STALL

It has often been said that a turbine engine stalls during acceleration. While this statement contains elements of truth, the statement must be qualified to get a true picture of the causes of compressor stall.

The T53 engine is subject to stall under the following operating conditions:

- Acceleration of the engine at low N_1 speeds, engine unloaded.

• Acceleration of the engine at high N_1 speeds, engine loaded.

• Acceleration of the engine under low temperature conditions.

The accelerations mentioned above may be broken down into two broad categories: acceleration in rpm ranges below those required for flight and acceleration within the flight rpm range.

The T53 series of engines are free power turbines. This type of engine uses an N_1 (gas producer) section which develops the power within the engine and an N_2 (power turbine) section which delivers the developed power to the airframe. This free turbine feature allows us to extract a variable power from the engine at a constant output shaft (N_2) rpm. It should be noted here that N_1 rpm must be increased in order to increase the power output of the engine. This is true because power is dependent on mass airflow through the engine. Low power and/or idle would then be obtained at a low N_1 rpm.

ACCELERATION AT LOW N_1 SPEEDS

The gas turbine powerplant is called upon to operate under various conditions of power and rpm. It stands to reason that if the engine is designed to be most efficient within the power/rpm range where it will normally be operated, it will be less efficient in other power/rpm ranges.

When the T53 engine is operated at a low N_1 rpm, such as flight idle (56 to 58 percent N_1), the compressor output is in excess of that required by the engine. This will result in an increase in the pressure ratio across the compressor. The pressure ratio is the ratio between air inlet pressure and compressor discharge pressure.

Too rapid acceleration within this rpm range increases the ratio and tends to choke the rear stages of compression. This decreases the already low mass airflow through the compressor. Remember that if rpm is increased without a corresponding increase in mass airflow, the effective angle of attack of the compressor blades is increased.

The fuel flow schedule of the fuel control is programmed to allow mass airflow to increase faster than pressure ratio. While this avoids compressor stall, it also results in slow acceleration rates.

To increase the acceleration rate, T53 engines incorporate a compressor air bleed. This allows air to be vented overboard at the fifth stage of compression during acceleration at low N_1 rpm to decrease pressure ratio. By this means, the acceleration rate of the engine is increased without the risk of stall. The air bleed feature of the T53 has eliminated stall in the low N_1 range as long as the unit is operative and properly adjusted.

ACCELERATION AT HIGH N_1 SPEEDS

The speed range under consideration here will be 74 to 100 percent N_1. Rapid acceleration within this range is usually encountered during power recovery from an autorotation and/or rapid application of collective at a high power setting. The acceleration rate within this range is determined by the fuel control, specifically the main fuel pressure regulator. The pressure regulator controls the acceleration rate by setting the fuel pressure across the main metering valve in the fuel control.

An increase in pressure will result in an increase in fuel flow for any given request for acceleration. An increase in fuel flow results in higher temperatures and pressures in the combustor and thus more power available to drive the N_1 system. This in-

compressor stalls can be very frightening if the pilot doesn't know what to expect

crease in combustor pressure will also cause a back pressure on the compressor, decreasing mass airflow. An increase in N_1 rpm and pressure ratio without an increase in mass airflow will bring us into the stall zone.

When stall is encountered within the N_1 range in question, the normal remedy is to adjust the setting on the main fuel pressure regulator. The regulator is preset to give maximum acceleration rate without entering the stall zone.

ACCELERATION AT LOW TEMPERATURE

The fuel control of the gas turbine engine delivers a metered amount of fuel to the combustor. As ambient temperature drops, the amount of fuel flow required by the engine increases.

This is because the air becomes more dense with a decrease in temperature and a greater amount of fuel is required to maintain a proper air/fuel ratio. This dense air also requires that a greater amount of energy be expended to compress it into the proper pressure ratio. The extra power required by the N_1 section can only come from an increase in fuel flow. This increase in fuel flow will result in an increase in N_1 rpm at a rate which may, due to the greater inertia of the dense air, exceed the rate of increase in mass airflow.

The fuel control of the T53 engine monitors inlet air temperature in order to regulate fuel flow.

The fuel control is programmed to provide fuel flow to the combustor which varies between two limits. The low limit is known as the steady state line. If fuel flow drops below this limit, the engine will decelerate or perhaps flame out from fuel starvation. The high limit is known as the stall line. When fuel flow exceeds this limit, the engine is subject to compressor stall. The variation between the high and low limits is known as margin.

It will be seen that an increase in pressure ratio or N_1 rpm will result in a reduction of fuel flow margin. The same is true for a decrease in mass airflow or inlet air temperature. Thus as ambient temperature drops, there is a decrease in fuel flow margin.

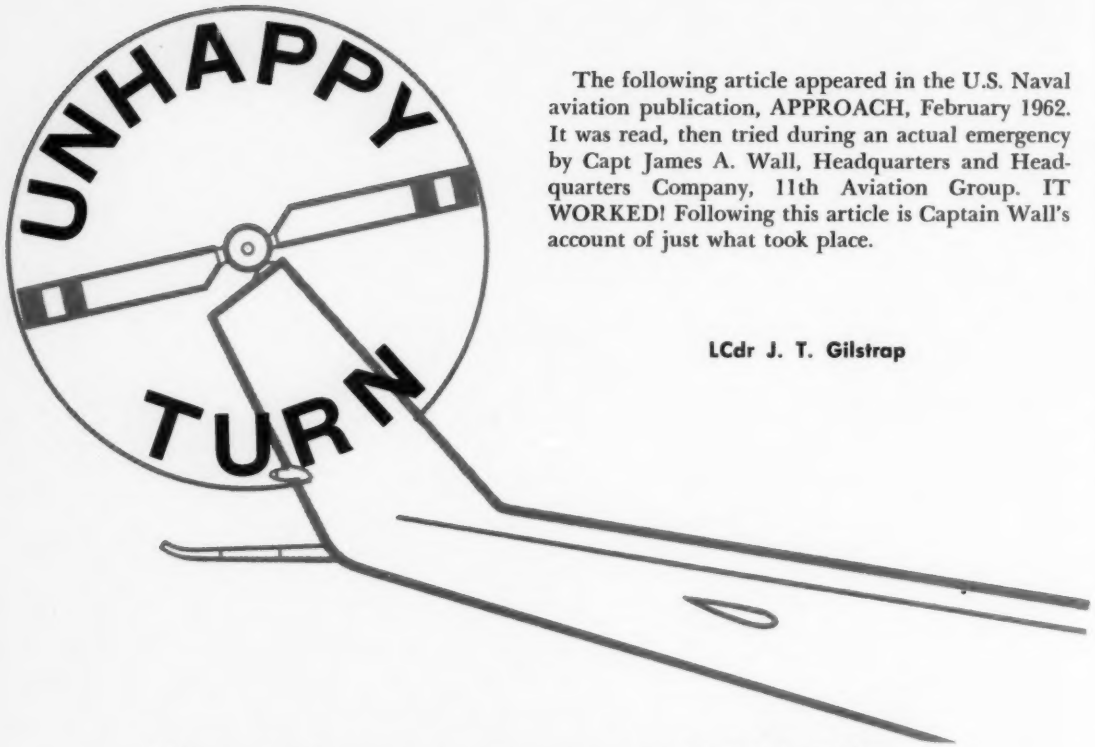
For the reasons shown above, violent applications of power should be avoided at low ambient temperatures. Under these conditions the fuel flow required to obtain this power might be in excess of that allowed by the high limit of the margin curve. Due to the hydromechanical construction of the fuel control, there may be sufficient lag in its operation to allow fuel flow to overshoot into the stall zone. Gradual applications of power will prevent stall under these conditions.

ACCELERATION WITH BLEED AIR DRIVEN COMPONENTS IN OPERATION

T53 engines have a bleed air fitting which allows high pressure air to be drawn from the compressor at the diffuser. This air is used on the UH-1B to drive the engine/transmission oil cooler blower. The turbo blower is in operation at all times; however, the amount of air required to drive it is only a very small percentage of the total airflow through the engine and thus the effects of its operation on the engine may be considered negligible.

CONCLUSION

The fuel control and other auxiliary systems of the T53 engine have done much to eliminate compressor stall. Normally stall could become a problem only at low ambient temperatures. When operating at low temperature, the pilot should remember not to make rapid applications of power.



The following article appeared in the U.S. Naval aviation publication, APPROACH, February 1962. It was read, then tried during an actual emergency by Capt James A. Wall, Headquarters and Headquarters Company, 11th Aviation Group. IT WORKED! Following this article is Captain Wall's account of just what took place.

LCdr J. T. Gilstrap

Chopper readers may or may not agree with LCdr Gilstrap's interesting discussion of tail rotor failure in flight. While the subject is somewhat controversial, the more thought provoking discussion there is on subjects such as these, the more knowledge and understanding is gained. Although desirability of the "run on" type landing under certain circumstances as suggested by the author can't be ruled out, in general NASC (Naval Aviation Safety Center) prefers the final approach and landing to be in full autorotation. Incidentally, recommended flight manual changes on the subject are presently pending.

How to train for inflight tail rotor failure

AS THE OPINIONS fly thick and fast on the subject of "what to do in the event of a tail rotor failure," it is interesting to note that there is always someone to add fuel to the flame.

The number of helicopter pilots who guessed wrong when their helicopter became a misguided missile due to the loss of a tail rotor are in the 95 percentile. It's nice to be average, but it's a lot better to be right. The factors that present themselves when you and your tail rotor part company must be understood to be met with proper action.

Let's get fundamental—the whole purpose of the tail rotor is to compensate the torque in the engine-to-main-rotor couple. It provides control around the helo's vertical axis by creating thrust to the right in powered flight, proportional to the amount of left rudder being displaced and to the magnitude of the torque couple.

In the realm of unpowered flight (autorotation) the tail rotor creates thrust to the left, in proportion to the amount of right rudder applied beyond the position where the tail rotor creates zero thrust. It is recommended that these points be fully understood as the first step toward standardizing a safe and completely reliable procedure to be followed in the event of tail rotor failure.

The following items should be included in all transition/familiarization syllabi for single rotor helicopters:

1. Note the position of the rudder pedals while in a stabilized, straight-in autorotation at the normal, recommended airspeed.

This rudder position *must* be slightly beyond the zero tail rotor thrust position in order to maintain balanced flight, since the friction in the system tends to carry the fuselage around the vertical axis in the same direction as the rotor.

2. Place the rudder pedals in the position found in step 1 while in fast cruise and observe the effects to the flight performance.

3. Gradually rotate the nose upward until airspeed stabilizes at that recommended for climb.

4. Gradually add power at the recommended climbing airspeed (still holding the same rudder position) and note the nose deviation to the right as normal climbing manifold pressure is reached.

The cyclic will probably be left of center to keep from turning, so try to center it to feel the effect.

5. From the normal climb, ease the cyclic aft and see how slowly the helicopter will fly while maintaining climbing power and holding to the same track with left cyclic. When the angle between the longitudinal axis of the helo and its track reaches 45-50°, it's time to quit. This maneuver will show you what the bird will do without a tail rotor, under the conditions simulated.

If the limits of the maneuver noted here are reached anywhere along in the process, check the rudder position (a good job for the copilot). If the rudder position is correct, approach the limits of the maneuver again, but favor less power and more airspeed to find the actual limits under varying circumstances, plotting airspeed against manifold pressure with a constant rpm.

The next step is to plot airspeed against manifold pressure with constant altitude and rpm.

Now is the time to land and think about what this experiment has told you — to wit — the limits of stabilized (unaccelerated) flight compatible with the loss of your helicopter's tail rotor.

Only a few elements are now unaccounted for in the "for real" emergency.

1. Occurrence at a time when flight is not compatible with tail rotor loss (too much power and/or too little airspeed).

2. Pilot reaction.

3. The accelerated rotation about the aircraft's vertical axis at the time the tail rotor is lost and the initial action necessary to cope with it.

4. The alteration of the center of gravity brought about by the separation of a structural member (ouch!).

5. The landing!!

Regardless of his position, the pilot's first instinct should be to lower the collective except while hovering, at which time he has no alternative to splitting the needles. This is, of course, to lessen the torque couple that impels the helicopter into clockwise rotation about the vertical axis. A quick

evaluation of his circumstances in terms of the above experiences will tell the pilot if he is in real trouble and a conditioned reaction should bring the aircraft quickly under control.

If the helicopter is not making enough airspeed to prevent a rotation beyond 90° from the original heading, the helo will soon be completely out of control around the lateral axis unless an autorotation is entered immediately. This unhappy turn of events is caused by the blades flapping upward, into the direction of the relative wind (now rearward), beyond the limited capability of aft cyclic to pull the nose up. The resulting maneuver is a rearward flare, bringing the nose attitude acutely down. This too can be recovered from with appropriate control and sufficient altitude, but the aft cyclic that the pilot would instinctively hold to pull the nose up would cause the blades to cut off the tail when the flare dissipated and flapping action diminished.

So maybe it can fly without a tail rotor! Great! But what about the landing?

A landing can be accomplished safely upon any smooth surface which will allow a 300-400 foot rollout. It can be done *with* power and *with* directional control to the degree allowed by the control the pilot has with his throttle to adjust torque. Here's how it's done.

Let's take it from slow cruise at 200 feet altitude. Line up the track with the runway and commence a standard letdown, but maintain gliding airspeed to about 30 feet altitude. Interrupt your glide with a gradual flare while gently increasing rpm about 200 turns above normal cruise setting (3400 in TH-13, 2600 in UH-19). A slight overspeed is better than a scraggled helicopter. The nose of the helo will be 10° to 30° to right of track as rpm is increased, but don't sweat it.

Follow through with the normal running landing procedure from the most highly rotated nose position, let the nose fall through and, just before ground contact, smoothly back off on the throttle at a rate which will cause aircraft alignment with the track and keep it there through touchdown. Once on the deck, bottom the collective, get on the brakes, and maintain heading control with the throttle. ON throttle — RIGHT rudder; OFF throttle — LEFT rudder.

This landing technique can be easily simulated by positioning the rudder pedals in a manner similar to that established in the earlier experiments. Such simulation could be cheaply and safely done in HTL skid or wheel configured helicopters. The larger articulated helicopters' rotor systems might possibly be endangered.

So why not autorotate? In autorotation there is *no directional control* and, unless zero airspeed is attained in the flare, a groundloop is almost certain to result.

The autorotation is a standard maneuver to be practiced to prepare for the eventuality of engine failure. It would be interesting to know how many victims of tail rotor failure have also experienced an engine failure. In other words, this just might be a very worthwhile maneuver to standardize for single rotor helicopter outfits.

If you ain't tried it, don't knock it.

This is Captain Wall's account of the emergency, the procedure he used, and his recommendations

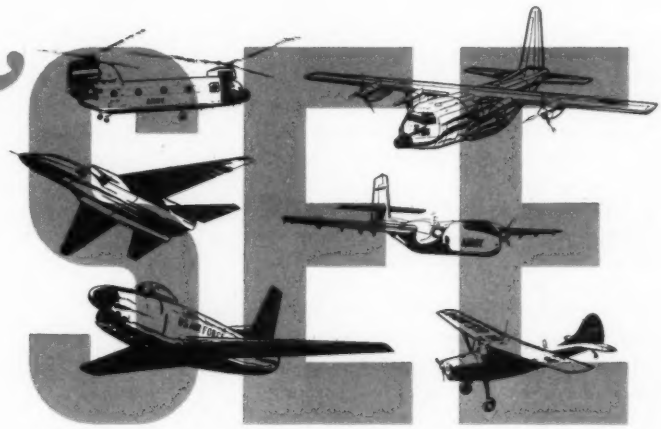
At approximately 1800 hours, 6 September 1963 an approach was initiated to Warner Robins AFB, Ga. After passing over the active runway at approximately 200 feet a moderate flare was initiated. As the airspeed reduced to 60 knots, the UH-1B began to yaw slightly to the left. Right pedal had no effect. A cyclic turn to the right was made to parallel the taxiway of intended landing. Application of both right and left pedal had no effect on directional control.

At approximately 50 feet and 30 knots a go-around was initiated. The helicopter yawed to the right about 30°. As airspeed increased no yaw tendency was noted. During the go-around a point of intended touchdown was selected on a sod area paralleling the active runway. A crosswind from the right existed. On the downwind leg the throttle control was placed in the emergency position. This was to allow engine torque to assist in directional control.

A shallow final approach was initiated at 60 knots. Tests on final approach indicated directional control could be maintained with engine rpm for slight adjustments of collective pitch. The helicopter touched down on the sod at approximately 15-20 knots maintaining a straight track. As groundspeed reduced, directional control was lost and the helicopter began a slow right turn, stopping with a heading approximately 60° to the right of the touchdown track.

It is recommended the crosswind component be from the left to assist in directional control.

LOOK & SEE



THERE ARE several ways to study the probabilities and possibilities of mid-air collisions and near misses. One is through statistics. Of 102 SHARE IT forms received during the past several months, 68 (66 2/3%) described near misses of two or more aircraft. Many of these appeared in the March issue of CRASH SENSE. If we assume that 1 percent of all near misses were reported, we can estimate 6,800 near misses.

Statistics can only give us numbers. If you're not a statistician or slide rule addict, numbers mean very little. They can tell us the aircraft population is exploding; they can tell us about increasing speeds and closure rates; and they can tell us about high density areas. *But they can't tell us about people.*

crash sense

PREPARED BY THE U. S. ARMY BOARD FOR AVIATION ACCIDENT RESEARCH

LOOK & SEE

The truth of the matter is that aircraft don't have midair collisions and near-misses – it's *people* who have them. To understand and correct the problems which result in collisions and near misses, we have to look at them through people – *through human traits and failures.*

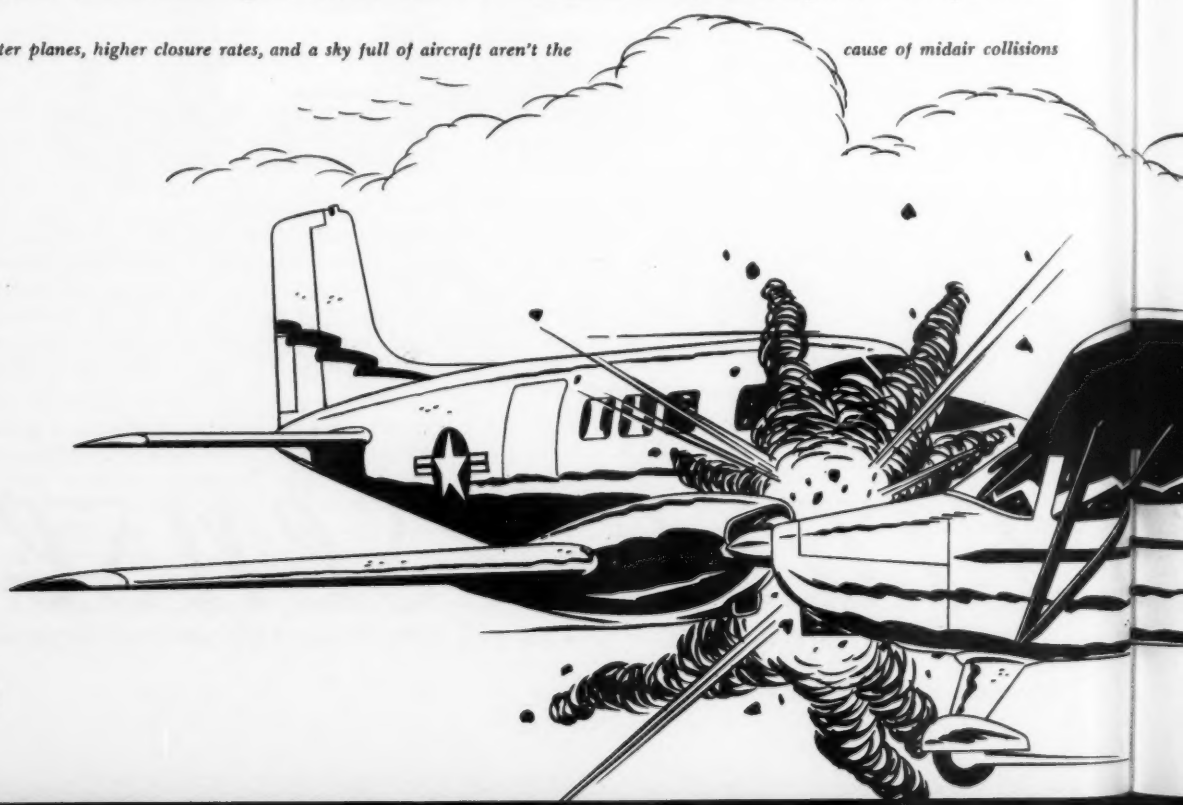
Probably the most important trait demanded of aviators is alertness. The need for alertness is always there in flight. Nowhere is this more evident than for the instrument instructor or the pilot flying as observer while another practices hood flying. Instrument facilities are crowded with aircraft, not only with arriving and departing commercial traffic but with other instrument trainers, business, and private aircraft. While radar and traffic control help, the burden of responsibility for avoiding other aircraft in VFR conditions still rests squarely on the pilot.

A U-8F was practicing low freq and ADF approaches to a civilian airport. Aboard were two highly experienced Army Aviators, one with more than 6,000 hours and the other with more than 3,000 hours. A civilian light airplane took off a few minutes before the U-8F was cleared for a straight-in, low approach from a low freq radio fix. The pilot of this airplane had just received his private license and had logged 50 hours. The stage was set. Inexperience, another human phase we all pass through, was in the cockpit of the light aircraft. Twelve minutes after it took off, the U-8F reported over the outer marker outbound. Five minutes later, the two aircraft collided almost head on at an altitude estimated at 2,000 feet.

Inexperience and lack of alertness played major roles in another mid-air collision a few months later. This time, two OH-23Ds were approaching a stagefield. Aboard one were an IP and student. The other was flown by a solo student. The dual helicopter, close behind the solo aircraft on downwind, turned inside the solo aircraft on base, turned final, and lined up to land on the first lane. The solo OH-23 turned a wide base, overshot the first lane on the turn to final, and completed the turn to final between the first lane and the second. It continued the turn back to the first lane and collided with the dual Raven at approximately 300 feet.

Stiff necks were apparent in a third mid-air collision of two CV-2Bs. A flight of four airplanes was

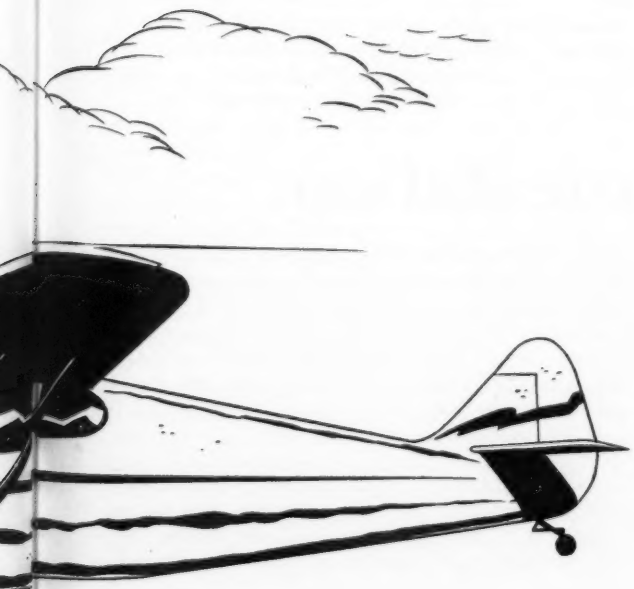
Faster planes, higher closure rates, and a sky full of aircraft aren't the cause of midair collisions



in right echelon formation. The copilot of the lead Caribou gave a hand signal for the no. 2 plane to cross to echelon left. The signal was repeated three times before the no. 2 airplane began to drop back and cross under. In the meantime, the no. 3 plane crossed over behind and above the lead aircraft and attempted to drop into no. 2 position. It collided with the original no. 2 craft and both crashed.

Nonalertness is the common denominator of these three accidents. It is also apparent in the 68 near misses reported. The only difference between the collisions and near misses is that at least one pilot was alert enough to see and act in time to avoid collision. But this only answers the question of *what* causes collisions and near misses. Like statistics, this information is of little value unless we know the answers to *why*.

One answer to *why* is that aviators don't know how to look. While this applies more to inexperienced pilots, it is by no means confined to this group. Fledgling aviators are taught the mechanics of looking around from their first day in the air. They look because their instructors tell them to look, but they see very little. Gradually, as they build experience, they begin to see and recognize other aircraft. They build and store mental images of other types and sizes of aircraft as they appear from various distances, from below or above, closing, or going further away. Hopefully, they learn what to look for and how to see from the air. But the difference between looking and seeing is a wide gap to bridge.



If you are reading this with concentration, you are at this moment unaware of what is taking place around you. In your conscious effort to absorb and understand these words, you have excluded all else —unless you're one of those rare geniuses with a simultaneous multichannel brain. Most of us come equipped with single-channel transmitters and receivers. We have to consciously tune in what we're receiving, either orally or visually, for it to be transmitted to our brains for action. Our brains also contain built-in censors. If we can't believe what we see, our eyes may focus on it, but we won't consciously see what we're looking at if it fails to pass this censorship.

Human visual perception has been compared to reading a large newspaper by the narrow beam from a pencil flashlight. Though our eyes are capable of taking in the whole newspaper, our minds limit what we can see and comprehend. Our area of conscious attention is not nearly so large as the area our eyes can see. But the smaller area of conscious attention determines what we can see with perception and understanding.

What has all this to do with mid-air collisions and near misses? Simply this: a pilot *must* be able to divide his attention between flying the aircraft, planning ahead, and remaining alert for other aircraft. He must make his single-channel receiver juggle these three items every second he is in the air. The faster the aircraft, the more crowded the air, the faster this mental juggling must be.

Another answer to *why* is *fatigue*. The suggested maximum flying hours in AR 95-17 are not just arbitrary figures. They were developed through long experience as the maximums which can safely be flown by average pilots under normal conditions. One of the pilots in the mid-air collisions described had exceeded this recommended monthly maximum by more than 35 hours. You can't expect tired or exhausted pilots to maintain the degree of alertness necessary to avoid near misses and collisions.

Still another answer to *why* is *drugs*. Another pilot involved in the collisions described had a cold and was taking a patent medicine. He had not reported his illness or the medicine he was taking to the flight surgeon. The patent cold remedy he was taking contained a sedative. This agent causes drowsiness and a slowdown of perception and reaction time. He definitely should not have been flying while taking the drug.

We'll end with a hair-raiser that happened dur-

LOOK & SEE

ing a recent night training flight. Two O-1A student pilots had just been checked out in the local pattern. The weather was clear with 10 miles visibility.

Student A was climbing to traffic pattern altitude after takeoff and student B was making a go-around. Procedure called for the Bird Dog on go-around to clear to the inside of traffic and climb out parallel to the runway. Student B was in level flight at approximately 87 kts, and student A was in a climbing attitude at approximately 69 kts. The go-around airplane overtook and passed over the right wing of the climbing aircraft. Its tail wheel struck the top of the right wing of the climbing aircraft about 6 feet outboard of the wing root. There was no damage and both students landed without further mishap.

All navigation lights and the rotating beacons of both aircraft were on and functioning properly at the time this happened. Since the mishap took place approximately ½ to 1 mile from the upwind end of the runway, it could not be determined whether one or both of the students allowed their upwind ground tracks to vary. The go-around procedure called for a minimum of 500 feet of horizontal separation. Neither student saw the other Bird Dog until the tail wheel hit the wing.

Beverly Howard, internationally famous aerobatic pilot and president of Hawthorne Aviation, has spoken to many graduating classes of military fliers. He always ends his talks with these words: "Remember, you fly with your head, not your hands and feet." Mr. Howard's advice is sound. To it can be added: You look with your eyes, but you see with your head. Are YOU looking *and seeing*?

Spatial Disorientation

things can get hairy when the seat of your pants flying tells you one thing – your instruments something else

In a different class of LOOK and SEE are accidents and mishaps from the loss of outside references, or where is up? The following examples were taken from a study entitled "Disorientation Experiences of Army Helicopter Pilots" by three flight surgeons, Capt Frank W. Ogden, Maj Quitman W. Jones, and Lt Col Harold R. Chappell.

Example 1

A CH-21 was returning to its home base in marginal weather conditions after a search and rescue mission. The crew did not check the weather before heading home, though 5 hours had elapsed.

Alertness is probably the most important trait demanded of aviators

Visibility became very poor so they followed a highway at 200 feet altitude. Fog was encountered momentarily, and they lost visual contact. The pilot attempted a climbing left turn, but began slipping to the left and losing altitude. He stated that he had vertigo. They broke out of the fog and the copilot righted the Shawnee. The pilot again took the controls and they again entered fog. The pilot attempted to regain visual reference and lost control of the aircraft. It slipped backward, then crashed nose down into some trees, killing the pilot. The copilot and crewchief were injured, but they survived to give a firsthand account of the occurrences.

Example 2

A flight of seven CH-21s were on a ferry mission from one post to another. Weather conditions were deteriorating. The flight commander ordered the flight to climb through a hole in the overcast and proceed on top until they had passed the front where the weather was reported clear. In doing this, the entire flight entered instrument conditions and a 180° turn was ordered. However, several pilots became disoriented and three lost control of their aircraft. Two of them crashed, killing all aboard; the third pilot regained some control prior to ground contact and the occupants survived but with serious injuries.

Example 3

A CH-34 was on a cross-country flight when it encountered snowshowers and was forced to land in an open field. The crew waited several minutes; then believing the snowshower had subsided, they took off again. After flying 300 yards, the instructor pilot elected to land again. At approximately 30 feet of altitude, visual reference was lost in blowing snow. The Choctaw drifted blindly to the rear and to the right until it struck the ground, skidded and rolled over. There were no injuries, but an expensive aircraft was a total loss.

These were expensive lessons. The total cost to the Army in loss of hardware was $4,500,000. The loss of life and injury cannot be reduced to dollars and cents. In view of training costs and anticipated career utilization of Army Aviators, a value of $1 million has been assessed. We lost 20 of these million-dollar aviators, plus 23 other valuable men. This must be eliminated or reduced.

Example 4

A CH-34 pilot was flying at midnight in very dark conditions. Most of the lights on the ground were out. The helicopter suddenly entered a cloud, and the copilot took control and attempted to keep the aircraft in level flight without use of instruments. The pilot felt that the nose was rapidly turning to the right and that they were losing altitude very rapidly. He increased collective pitch, but the aircraft continued to fall, with both pilots frozen on the controls. They broke out of the cloud at approximately 1,000 feet in an extremely nose-high attitude. By reference to lights on the ground, they righted the aircraft and safely landed in a large plowed field.

These two aviators are still flying. They learned the importance of instrument training by this harrowing experience.

Example 5

A CH-21 pilot took off one dark night with a "bad head cold." He was unable to correct the skidding which occurred, so he climbed to cruise altitude while still skidding, then turned the controls over to an unqualified copilot until he could regain his orientation.

It is remarkable that he could maintain control and that the aircraft was able to climb while skid-

Spatial Disorientation

ding, but how much better it would have been if he had been properly trained on instruments. It would appear easy to correct such a condition, but when your inner ear and the "seat of your pants" are telling you one thing it is extremely difficult, without proper instrument training, to believe the attitude gyro and other related instruments.

Example 6

While flying left echelon formation at night, a flight of UH-1Bs entered actual instrument conditions. The flight leader turned left into the flight and caused the pilot of one of the following Hueys to become disoriented. The disoriented aviator turned the controls over to the other pilot while in an unusual attitude. Then he talked to the other pilot regarding airspeed, attitude, altitude, power, etc. By cooperating in this manner, they were able to get the aircraft coordinated. The pilot who took control made this statement: "I feel that without him talking to me on intercom, we would have crashed, because at times I would not believe the instruments."

In this case, a coordinated effort very likely saved lives and aircraft, and permitted the mission to be accomplished.

Example 7

During sling operation with a CH-34 at night without lights, the pilot was unable to maintain proper attitude in hovering for hookup. Once, after hooking up and attempting to fly away, the helicopter assumed such a nose-low attitude that the copilot had to recover.

Example 8

A formation of four UH-1Bs was returning to home base after a maneuver when one helicopter had inverter failure. The battery soon became discharged, and the instruments failed. Weather conditions became marginal. Visual contact was lost with the other aircraft and the terrain was visible only intermittently. When the pilot became disoriented and began to lose control, the copilot took the controls. Between one and two minutes later the copilot became disoriented. By this time the pilot had regained orientation by looking down and to the side, so he resumed control, only to lose control again after one or two minutes. They proceeded in this fashion until they found a field and landed. They remained on the ground until the inverter was repaired.

Teamwork again averted a serious accident, though a 180° turn at some earlier point might have been a better choice.

Example 9

While on a medical evacuation mission of a seriously injured patient on a dark night, an OH-13 pilot was searching the ground for the hospital loca-

"I feel that without him talking . . . we would have crashed . . . because I would not believe . . . instruments."

tion when he felt the aircraft falling off to the left in a descent toward the side of a mountain. He had been cruising at 80 mph, but had apparently inadvertently applied some constant back pressure on the cyclic that resulted in loss of airspeed to zero, and he was descending rapidly before he realized it. A contributing factor may have been the airspeed indicator, which reads the same for 0 and 80 mph, so a quick check of this instrument would not have alerted him to the danger. He was able to recover his airspeed, and he proceeded without further disorientation.

This is an example of poor instrumentation, as well as the problem of night flying in an aircraft without instrumentation for IFR flying.

Example 10

An OH-23 pilot was flying at night over the desert when some rather strange things occurred. He was returning to his base camp 45 miles away, so he climbed to 2,000 feet to see a 150-watt bulb attached to a radio antenna at his destination. He located it without difficulty since there were no other lights, and proceeded to fly toward it. After a short time he noted that the light appeared to be moving to his right and this rather confused him. By the time it got around to the right door he was extremely confused. The wind was whipping through the open cockpit, practically blowing his hat off. He finally descended and was able to obtain some ground reference. He was, in fact, flying sideways, almost backwards. He was able to correct this and make a rather satisfactory landing.

This was the result of a phenomenon of vision known as autokinesis in which, by fixing the eyes upon a single light source, the light seems to move about in random fashion. In this instance, when the light would seem to the left, the aviator would unconsciously make a small correction to the left, so the actual position of the light was located to his right side.

It is unusual for this phenomenon to cause this degree of disorientation, but in some situations even minor degrees could result in disaster. Formation flying at night with an aircraft ahead displaying a single position light visible to the pilot is such a hazardous condition. Disorientation in this type of situation could very easily result in a mid-air collision.

Incidents of spatial disorientation can be avoided by observing two precepts: Believe your instruments and don't get in over your head—if your aircraft is not equipped for IFR flight, stay away from the weather.

Why The Change?

Lieutenant Ellery F. Calkin, Jr.

THE A-20 FIRE extinguisher has steadily been replaced by the 1301 or $CBrF_3$ fire extinguisher. At the present time all our aircraft equipped with hand or portable fire extinguishers have the 1301 type.

Both extinguishers are similar in many respects. Their total weights are the same (6¾ lbs); they have to be inspected every 6 months; both have an internal pressure supply; and both are relatively the same size.

Why the change? They differ in two very important ways. The chemicals used in both are good extinguishing agents, but the monobromotrifluoromethane ($CBrF_3$) in the 1301 is almost twice as effective as chlorobromomethane ($CH_2Br\,Cl$) used in the A-20.

Probably the most important difference between the two is the toxicity of the chemical agents. In concentration of 2 to 2½ percent by volume, gases or vapors from the A-20 are lethal or produce injury under exposure for 1 hour. In concentration of 20 percent by volume, gases or vapors from the 1301 do not produce injury after a 2 hour-exposure period.* This alone is enough reason for the change.

In using the 1301 one important fact must be remembered: once triggered, *the extinguisher must be replaced*. The pin which punctures the diaphram will not reseat itself well enough to contain the gases for any length of time.

***Fire Protection Handbook*
**Army supply manuals list the 1301 type as CF_3Br.*

LOW POWER

Continued from page 33

Incipient stall may produce roughness or surging with or without audible accompaniment of rumble, drone, etc. More pronounced stalls may produce noises varying in intensity from the sounds of pistol shots to cannon fire and can be very frightening if the pilot does not know what to expect.

The fuel control schedule when operating in AUTO is modified to avoid this surge condition during acceleration. This is accomplished by the gas producer (N_1) speed, temperature and altitude, or density, controls.

These components sense their individual requirements and, in turn, combine their functions to send an integrated signal to the main metering valve in the fuel control.

First, let us cover density altitude by saying that the higher the density altitude, the longer the time required to accelerate. Compressor blades suffer aerodynamically just as do the wings of an airplane or rotor blades of a helicopter.

Second, for a given density altitude, the speed at which the compressor is turning when asked to accelerate will govern the rate at which it can be accelerated. As mentioned previously, the slower the compressor is turning, the slower it can accelerate.

Another factor that influences acceleration from low power is optimum output shaft or engine speed (N_2). Optimum N_2 is defined as the speed at which the power turbine is capable of absorbing the maximum amount of energy available in the gas flowing through the engine.

Normal governor operation is in the 5800 to 6600 rpm range. At low powers, or flight idle, the optimum engine speed (N_2) is at a much lower value than the N_2 governor is set. As the gas flow increases, by increasing the gas producer speed (N_1), optimum engine speed (N_2) also increases, seeking to maintain the most efficient engine speed, which is in the normal governing range.

It is realized that only a small portion of the total operating time is in the low power range, but the pilot has to use low power during every landing approach and every practice autorotation. Here is where operating technique enters the picture.

During normal low power operation, full down collective and twist grip wide open, the gas producer speed (N_1) will be approximately 72 percent (engine speed 6600). A rapid application of collective pitch may demand more power than the engine is capable of producing. This results in a dropoff of N_2 and rotor speeds to a critical point if the ship is heavily loaded.

The preferred method is to raise the collective slightly while still continuing the landing approach. This will allow the gas producer speed to increase, thereby reducing the time required for a full power recovery after the flare is executed.

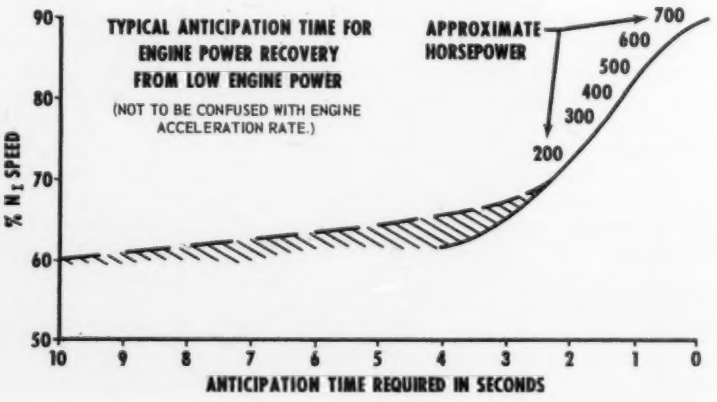
In flight, a power recovery from a practice autorotation has to be anticipated by a period of time which could be in excess of 10 seconds. This, naturally, depends upon how far the pilot has allowed N_1 and N_2 speeds to drop off, along with the ambient temperature and altitude.

Normally the gas producer speed (N_1) will be approximately 60 percent. This is with the twist grip rolled off to the flight idle position.

To effect a power recovery the pilot first has to roll on the twist grip to full open. Then by monitoring N_2 and rotor speeds apply a small amount of collective, after the tachometer needles are together. A glance at the N_1 indicator to see if the speed is increasing will also show that the engine is responding normally. Caution is required during the application of collective so that the rotor speed is not reduced to a critical point.

A little practice with the above technique in mind will produce a very good and powerful response from the engine. The curve shown gives the average anticipation time required to effect a power recovery of 90 percent gas producer speed on N_1.

A little planning will preclude compressor stalls and increase the safety of low power turbine operations.



Usual Duty in an Unfamiliar Country

THE STOIC majesty of a marble Buddha and concrete bunkers reminiscent of Normandy beaches — these are daily sights for an Army Aviation transportation company in the Republic of Vietnam.

Although the sights may be unusual, the company's mission is usual: recovery of downed aircraft and the supply and repair of damaged ones. Instead of trucks the transportation company's main vehicles are three CH-37s, one UH-1B, and one U-1A.

While direct support of aviation units assigned in its operations area comes first, the company provides backup maintenance support for other units in the RVN.

In a recent month the company received over 8,000 requests for parts, repaired 71 aircraft, and recovered several fixed and rotary wing aircraft. Since mid-1963 the unit has recovered 139 downed aircraft, including 54 Shawnee and 43 Hueys.

World's Fastest Rotorcraft

THE U. S. ARMY Transportation Research Command experimental helicopter XH-51A (below) recently flew at 242 mph.

The "rigid rotor" helicopter was flown under a high speed flight test program being conducted for the Army by the Lockheed-California Company. The test vehicle was modified by the addition of 15-foot stub wings and an auxiliary Pratt & Whitney J-60-P-2 jet engine mounted on the left wing to provide the data thrust necessary to attain speeds in excess of 200 knots. There was no modification of the original four-blade rigid rotor system which makes possible both "hands off" stability and a high degree of maneuverability.

—Lockheed News Release

A MODIFIED YUH-1B research compound helicopter (above) recently achieved level flight speeds of 250 mph. The hybrid Iroquois helicopter — modified by the addition of wings, auxiliary turbojet engines and a streamlined fuselage—was flown by Bell Helicopter Company test pilots at Fort Worth, Texas. (See DIGEST, Aug 64.)

Test flights were sponsored by the U. S. Army Transportation Research Command, Fort Eustis, Va., and are part of an overall high performance helicopter research program undertaken to give the Army data and engineering information necessary to design future high performance rotorcraft. USATRECOM currently has four other helicopter firms conducting high performance flight evaluations.